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*M. D. 1931.*





## Introduction

The results embodied in the following report were obtained in the course of a general helminthological survey of Southern Rhodesia during the year 1930. The work was undertaken on behalf of the London School of Hygiene and Tropical Medicine which, in conjunction with the Government of Southern Rhodesia, has established a Rhodesian Research Fellowship for the purpose of facilitating the investigation of disease conditions in the Colony. The present investigation was begun in May 1930 and continued until February 1931.

When the work commenced schistosome infestations were known to be present both in the Europeans and the Natives of the Colony. From the clinical standpoint, however, the disease was regarded as relatively unimportant as the gross manifestations of the disease, either in its urinary or intestinal form were rarely encountered.

Precise knowledge was lacking on the intermediate

molluscan hosts of the schistosome species met with in Rhodesia. Various fresh-water molluscs had, from time to time, been submitted to the Public Health Laboratory, Salisbury, but no animal experimentation had been carried out to determine the nature of the cercariae they chanced to harbour.

The possibility of the existence of reservoir hosts for mammalian schistosomes capable of parasitising man had not been investigated.

In the course of a few preliminary examinations it soon became apparent that schistosome infestations were much more prevalent amongst the Native population than had been hitherto suspected and on this account it was decided to devote as much of the available time as possible to a study of the schistosome problem.

While determining the incidence of the infestation amongst the Natives of the different regions of Southern Rhodesia, every opportunity was taken to investigate the bionomics of those fresh-water molluscs which constituted the intermediate hosts of the parasites. At the same time frequent autopsies were carried out on various mammals, such as monkeys, baboons, sheep, etc., for the purpose of detecting previously unsuspected hosts for the human schistosomes.

Rhodesia, Nyasaland, Portuguese East Africa, Bechuanaland or the Transvaal for the purpose of obtaining work



### Geographical Position

Southern Rhodesia is a wide tract of country of some 151,000 square miles lying between the Zambesi River to the north and the Limpopo to the south, and thus extends from latitude 15°36'S. to latitude 22°25' S. On the east and partly on the north it is bounded by Portuguese East Africa and on the west by Bechuanaland Protectorate. In the south, the Limpopo River separates Southern Rhodesia from the Transvaal, while in the north the Zambesi River intervenes between Northern and Southern Rhodesia.

### Population

The population of Southern Rhodesia consists of three big sections:-

1. The Natives
2. The Non-Europeans
3. The Europeans

The Native population is subdivided for official purposes into Indigenous and Non-Indigenous sections. The Indigenous group includes the descendants of those Natives who were living in the country at the time of the Occupation (1891). While the Non-Indigenous Natives are those who enter the Colony from Northern Rhodesia, Nyasaland, Portuguese East Africa, Bechuanaland or the Transvaal for the purpose of obtaining work

on the mines or elsewhere.

The Indigenous group consists for the most part of Bantus, who fall into two big categories.

1. The Mashona, who is believed to have come from the north of the Zambesi River and to be the true aboriginal of the district now known as Southern Rhodesia. At the present time he occupies the eastern half of the Colony. Prior to British occupation the Mashona suffered much at the hands of the war-like tribes south of the Limpopo River and as the term "Mashona" indicates, he came to be looked down upon as a slave devoid of the physical graces and mental cunning which characterised his conquerors.

2. The Amandabele (Matabele) occupy the western portion of the country. They arrived in Southern Rhodesia from the south and have a reputation of having been a fierce and hardy race of Zulu stock who drove the Mashona into the eastern half of the country. The eastern part of Rhodesia is referred to as Mashonaland in contra-distinction to Matabeleland - the land of the Amandabele (Matabele).

As already indicated, the Non-Indigenous Natives are those who have come from Northern Rhodesia, Nyasaland, etc. Large numbers of these Natives enter Southern Rhodesia annually - a sequel to the industrial and

agricultural developments occurring throughout the Colony. In some cases the Native immigrant settles permanently in the country, in other cases he works for a time, then drifts back to his homeland once more.

It was estimated (June 30th, 1930) that the total Native population of the Colony amounted to 1,040,000 of which a considerable portion consists of Non-Indigenous Natives.

The Non-European section consists of Asiatics and the "coloured" people and numbers about 4,000. The Asiatics are mainly Indians with a few Chinese and Japanese in addition. They run stores and market-gardens and serve as waiters, washermen and tailors. The "coloured" women are commonly employed as nurse-maids, cooks and the like, while the men find employment as waggon drivers and chauffeurs.

The European population as estimated by ordinary Census methods on 30th June, 1930, amounted to 48,400. This figure shows an increase of 9,226 on figures of the 1926 Census, indicating a relatively rapid increase on the part of the European population. From the standpoint of preventive medicine the importance of this increase lies in the fact that the European is being brought more and more into contact with the Native and his diseases and since the Native

is slow to adopt the sanitary measures of the white man, there must necessarily be increased opportunities for acquiring his diseases. It is obvious, therefore, that extensive medical surveys amongst the Native population, followed by the logical application of preventive measures must prove of mutual benefit to both Native and European.

#### Methods adopted in carrying out Field Investigations

It was decided that the incidence and severity of schistosome infestations amongst the Indigenous Natives could be investigated most satisfactorily in the Native Reserves. These Reserves are wide areas, scattered all over the Colony, set apart for the exclusive use of the Indigenous Native. There is now an increasing tendency for the Native to leave his Reserve and work in one of the towns, or in one of the mines of the Colony for a variable period and then return to his kraal. The women and children, however, rarely, or never, go outside the Reserve and afford a relatively clean index of the various parasitic diseases endemic in any given area, especially as intercourse between Reserves is restricted either by distance or some natural barrier and as Non-Indigenous Natives settle in and around the towns. Accordingly a series of short trips were made into representative Native Reserves and from 100 to 200



Natives of both sexes and all ages were examined for evidence of helminthic infestation.

Examination of entering Natives on the day of their arrival in Southern Rhodesia was also carried out. This examination was facilitated by the fact that Natives from Northern Rhodesia, Nyasaland and Portuguese East Africa can enter Southern Rhodesia only through certain frontier stations.

In regard to the general Native community consisting of varying proportions of Indigenous and Non-Indigenous Natives it was found that all races were represented in the admissions to the Salisbury Native Hospital. Consequently these admissions were taken to represent a cross-section of the general Native population and by means of a series of examinations of faeces and urine the incidence of schistosome infestations in that section of the Native population with which the European was most in contact could be readily ascertained.

The Non-European and European sections of the population were more difficult of survey on a large scale. The results recorded in the sequel were mostly obtained from patients admitted to the Salisbury Hospital in the course of the investigations.

When the examinations were being carried out under field conditions 5% formal-saline was added to

### Techniques adopted in the Routine Examinations

Examination of Faeces. In selecting a technique for the examination of faeces it was necessary to bear in mind that a very considerable proportion of the total examinations would be carried out under field conditions. A simple apparatus which would permit of a fair degree of concentration of the egg-content of a given sample of faeces was aimed at and finally decided upon.

The collecting apparatus consisted of a cylindrical glass tube 3" x 1", furnished with a cork stopper which carried a small aluminium spoon. In collecting the sample the individual was instructed to look carefully for the presence of blood or mucus on the surface of the faecal mass and to include any he might find in the sample. He was also instructed to include in his sample portions from the surface and from the interior of the faeces. In the case of liquid stools passed into a receptacle the native orderly was instructed to stir or shake the specimen thoroughly before selecting the sample. The glass tube was filled to about a third of its depth with the specimen.

When the examinations were being carried out under field conditions 5% formol-saline was added to

the tube to the depth of about  $\frac{1}{2}$ ". The Native would then add about  $\frac{1}{2}$ " of faeces and by thoroughly mixing one with the other made an emulsion which could be easily manipulated in subsequent stages of the examination. When the examinations were made in the laboratory the samples were only formolised when transit occupied more than 24 hours.

Examination of the Specimen. The first step in the examination consisted in thorough emulsification of the faecal sample. In the case of well mixed formolised specimens it was only necessary to add a little more water (tap-water or river-water) until the tube was almost full and shake, or stir, thoroughly until a good emulsion was found. When dealing with solid faecal material or a badly mixed formolised specimen the contents of the tube were emptied out into a mortar, a quantity of tap-water was then added and a thin faecal emulsion made.

The thin emulsion was then passed through a wire gauze sieve into a porcelain dish. (The sieve actually used was a small mesh tea-strainer). The contents of the porcelain dish were then transferred to a centrifuge tube and the specimen centrifuged (using a hand centrifuge) for a period of about thirty seconds.

The supernatant fluid was decanted off leaving

sufficient to make a thin emulsion with the faecal deposit at the bottom of the centrifuge tube. The deposit was thoroughly mixed with the fluid by means of a mounted cutting needle with a broad diamond-shaped head. A few drops of the emulsified deposit were then transferred to a glass slide, covered with a cover-slip and examined under the low power of the microscope.

The various parts of the apparatus required to be thoroughly washed between each test.

This technique could be utilised in the field as well as in the laboratory and native orderlies readily become proficient in its use. All types of eggs were thrown down by this method and the concentration was sufficiently adequate for the detection of even light infestations.

Examination of Urine. Just as in the examination of samples of faeces it was found that the results of urinary examinations were considerably enhanced if due regard were paid to the collection of the specimens. Whenever possible, the patient was instructed to empty his bladder partially and thereafter pass the residue into the collecting tube. These instructions were given on the assumption that the vigorous contractions of the bladder musculature at the end of micturition would serve to force eggs into the final specimen. When



a 24 hours sample was sent for examination it was allowed to stand at least 30 minutes (usually for a much longer period) and then the greater portion of the specimen decanted off.

The final procedure, whether dealing with a 24 hours specimen or a single specimen, consisted in placing a quantity of the urine (after being well shaken) into a centrifuge tube and centrifuging for about 30 seconds. The supernatant fluid was then decanted off leaving a few drops of urine which were shaken up with the deposit and transferred to, and spread over a glass slide and examined, uncovered, with a 2/3 lens.

### Historical

The existence of an endemic haematuria in Southern Africa was recognised by the early settlers in Cape Colony. Various views were held regarding the causation but the most favoured ascribed the condition to the presence of urinary calculi or gravel. The "gravel complaint" in turn was thought to be due to drinking gritty or sandy water which, in the towns, was distributed by open channels paved only in parts. Familiarity with haematuria was so marked that it came to be looked upon almost as a normal incident in the life of every young male. Furthermore, the absence of incapacitating symptoms, together

with the widespread belief in the spontaneous disappearance of blood from the urine soon after puberty, the apparent absence of complications and the failure of all forms of treatment eventually gave rise to the impression that the condition could be ignored with impunity.

This attitude to the disease was prevalent amongst the medical men of Cape Colony in the year 1864 when Dr. John Harley demonstrated, for the first time, the presence of bilharzia eggs in the urine of such cases. Harley was acquaint<sup>ed</sup> with the Bilharz discovery of S. haematobium in the human host in Egypt (1851) and with the descriptions of the bilharzia worm that had been given by Bilharz, Griesinger and others. Although unable to obtain adult worms from the cases under his observation, Harley made a careful study of the miracidium and states that "after careful comparison of the ciliated embryo, which I have described, with Griesinger's figures of B. haematobia, there remains sufficient differences to induce me for the present to refer the former to some other species; and from the locality in which I have discovered the parasite, I will call it Bilharzia capensis." It has since been shown that B. capensis is synonymous with S. haematobium.

In 1869, Harley described a further series of cases of bilharzial haematuria in Europeans and definitely associated the onset of the condition with

bathing in certain streams. While convinced that either a fresh-water mollusc or fish played a part in the life-cycle of the bilharzia parasite, he was unable to bring forward experimental proof in support of his view. He was also of the opinion that the parasite gained the urinary bladder per urethram rather than by the blood stream. This belief is still met with occasionally amongst the lay population of both South Africa and Southern Rhodesia. At the time of Harley's second communication the Natives of Cape Colony were thought to be exempt from the disease.

During the next few years there are frequent references both in German and in English literature to the occurrence of bilharzial haematuria amongst European settlers in different parts of Southern Africa.

An interesting light is shed on the attitude of practising physicians to bilharzial haematuria in a paper by Batho (1870). In giving the results of eight years' experience in Cape Colony, Batho states that endemic haematuria "must be regarded rather as one of the curiosities of pathology than as an affection of much gravity or importance".

Attention was first drawn to the presence of bilharzial haematuria in Natives by Lyle (1883). Amongst the Natives of the Zambesi Valley up to, and beyond the Victoria Falls, the condition was commonly

referred to as "Tanda maropa" - the passing of blood. Lyle was the first to recover adult schistosomes from the tissues of the urinary bladder and to describe the pathological changes they occasioned.. *cc in Rhodesia*

In 1884, Davies records an interesting case of bilharzial haematuria complicated by dysenteric symptoms in which terminal spined eggs were recovered from both urine and faeces.

During the early part of the twentieth century numerous reports were to be found on the prevalence of bilharzial haematuria amongst British troops stationed in South Africa and it was universally recognised that the condition regularly followed bathing in certain rivers and streams.

Turner (1908) gives a very complete account of the distribution of the bilharzia worm south of Lake Nyasa and from his account it is apparent that bilharzial infestations of the urinary bladder prevailed, in varying concentrations, both in Natives and Europeans all down the east coast and in many inland districts besides. At this time the lateral spined egg was not generally regarded as belonging to a separate species. Turner, however, makes reference to the occurrence of both lateral and terminal spined eggs amongst the Natives but emphasises the fact that the latter are much more common than the former. Meanwhile Miyagawa (1913-1914) in Japan and Leiper (1915) in Egypt had



conclusively demonstrated the relationship of certain fresh-water molluscs to the life-cycle of the human bilharzia worms. In South Africa the relationship of a fresh-water mollusc to the life-cycle of S. haematobium was first established by Becker. Early in 1916 he demonstrated mammalian cercariae in Physopsis africana and later in the same year recovered three adult male schistosomes (S. haematobium) from the portal vein of a guinea-pig which six months and eleven days previously had been given a subcutaneous injection of these cercariae.

Faust (1920) reporting on a number of P. africana collected by Cawston in Natal, states that larval forms of both S. haematobium and S. mansoni were found.

Porter (1920) carried out a series of investigations on cercariae derived from Limnaea natalensis and Physopsis africana and by means of animal experimentation claims to have shown that P. africana may serve as the intermediate host of either S. haematobium or S. mansoni, and that on rare occasions L. natalensis may also serve as intermediate host for S. haematobium. Later in the same year she found S. mansoni cercaria in specimens of Planorbis pfeifferi received from Natal.

In Southern Rhodesia bilharzia disease is first officially commented on in the Report of the Public Health Department for the year 1912. The disease is stated to

be "by no means uncommon" either in Europeans or Natives and is ascribed to bathing in certain pools and streams. The earlier reports on bilharzia disease refer to the urinary form only but in 1913 Sir Patrick Manson demonstrated the presence of lateral spined eggs in the faeces of two Natives resident in Southern Rhodesia. Subsequent routine examinations at the Public Health Laboratory, Salisbury, showed that schistosome infestations of the urinary tract were frequently met with in Natives and also to a varying extent amongst the school children of the Colony - particularly amongst the boys.

When the present investigations were begun any information regarding the presence of schistosome infestations throughout the Colony as a whole was based entirely on clinical reports, but, as gross manifestations of the disease, either in its urinary or intestinal form, were met with only occasionally schistosome infestations were, in the main, regarded as both rare and unimportant.

Mammalian schistosomes other than S. mansoni and S. haematobium had not been met with in Man nor had the intermediate hosts of the known schistosomes been ascertained. Finally reservoir hosts for mammalian schistosomes capable of entering the human host had not been considered.

The present account deals in turn with these

various aspects of the schistosome problem in Southern Rhodesia.

Statistical and Topographical Data

Schistosome Infestations amongst the Indigenous  
Natives of Southern Rhodesia

Sebungwe District

The Sebungwe district is a wide tract of country, containing several Native Reserves, lying to the north-west of Southern Rhodesia and separated from Northern Rhodesia by the Zambesi River. While the altitude of the Zambesi Valley as it runs through the Sebungwe district is in the neighbourhood of 1,000 feet above sea level the land rises abruptly to form a precipitous escarpment which reaches a height of 1,500 to 2,000 feet.

Geologically the sedimentary or volcanic rock formations which prevail in this area belong to the Karoo system which is here characterised by an upper stratum of red pebbly grit or sandstone. The meteorological data available for the district has been ascertained at the Native Commissioner's Department, Gokwe which is over 100 miles south-east of the Zambesi Valley but it is believed that the figures obtained apply with minor variations to the district as a whole.

The average rainfall over a period of 15 years is 30.47 inches, practically the whole of which falls in the five months - November to March. The average number of rain days in this period is given as 63.9 which may be taken to indicate that considerable flooding of the rivers occurs during the course of the rainy season.

The rivers and streams of the district all drain towards the Zambesi River and it appears that with the cessation of the rains they diminish rapidly in volume and in many cases are quite dry for several months in the year.

Apart from three or four Native Department Officials there is no permanent white population in the district. During the dry season Government Officials occasionally enter the region and from time to time a hunting party makes its way through Sebungwe to the Zambesi Valley.

The Natives of this district are of a relatively primitive type. They live in small communities on the kraal principle and number approximately 22,000.

It is apparent, therefore, that the Sebungwe district is essentially a Native area, remote from the white population of the Colony and rarely entered by Natives from the north of the Zambesi or from any of the surrounding districts.

The prevalence of schistosome infestations will



be seen from the following table which is based on the examination of Natives of all ages and both sexes.

Table I

<u>Parasite</u>	<u>No. of Examinations</u>		<u>Infestations</u>		<u>Percentage Infested</u>	
	<u>Total</u>	<u>Male</u>	<u>Total</u>	<u>Male</u>	<u>Total</u>	<u>Male</u>
<u>S. mansoni</u>	228	119	109	4	2	1.8
				2	1.7	1.8
<u>S. haematobium</u>	228	119	109	22	18	9.6
				4	15.1	3.7

### Darwin District

The Darwin District occupies the north-east corner of Southern Rhodesia and contains four large Native Reserves. The Mkumvara River and the Ruia River form the north-eastern boundary of the district dividing it from Portuguese East Africa.

The general altitude of the district lies between 3,000 and 4,000 feet. The Mavuradonna Range, which crosses the northern half of the area, reaches an altitude of approximately 5,000 feet, while the Umvukwe Mountains which share in the formation of the western boundary, rise in places to 6,000 feet. The Darwin area is thus an example of the "high veld" or plateau of subdued relief which stretches from the west-south-west to the east-north-east of the Colony.

Geologically the rocks belong for the most part to the igneous series - mainly granite and gneiss - with the exception of a relatively narrow basement schist area characterised by steep-sided hills in the southern half of the district. It is of interest to note that in the schist area the bush is dense and the grass long, whereas in the granite zones the bush is much more open and the grass shorter.

As in most parts of Southern Rhodesia, the Darwin rainy season extends from November to March although

negligible quantities of rain may fall in the months that precede and follow this period. The average annual rainfall calculated on observations at Mount Darwin extending over twenty-five years is 30.59 inches with an average of 64.6 rain days.

Although from the map the district appears to be fairly well supplied with rivers and streams the majority dry up completely in the course of the dry season except for a few, often widely scattered, residual pools upon which the Native (in common with the general animal life of the neighbourhood) is dependent for his water supply.

The Darwin district is peopled mainly by two groups of Bantu tribes, the Makorekore and the Watawora. Each group is subdivided into numerous tribal communities scattered over a wide area.

The White population is small.

The results obtained in this region were as follows:-

(see page 22)

Table II

Parasite	No. of Examinations		Infestations		Percentage Infested	
	Total	Male	Total	Male	Total	Male
<u>S. mansoni</u>	184	104	17	11	9.2	10.6
		80		6		7.5
<u>S. haematobium</u>	202	122	44	32	21.8	26.2
		80		12		15.0



Umtali and Melsetter Districts

The Umtali and Melsetter districts are mountainous regions constituting two of the boundary districts on the eastern side of Rhodesia where they join Portuguese East Territory.

The Umtali district is a well-watered area with a rich soil and a correspondingly luxuriant vegetation. The average annual rainfall is relatively high and varies in different parts of the district from 35.42 inches to 74.33 inches, with an average number of rain days varying between 65.4 and 106.1. In common with the greater part of the eastern half of Rhodesia this district is composed mainly of granite and gneiss with a soil which is fertilised by great diorite bars.

The Melsetter district is a relatively moist region with dense vegetation and in places, the remains of an old tropical forest. While the general altitude of the district lies between 5,000 and 6,000 feet, the land falls away to the west and south until at its most southerly point at the junction of the Sabi and Lundi Rivers the elevation is just over 1,000 feet. This region also experiences a high

annual rainfall which varies between 46.73 inches and 66.22 inches. The average number of rain days is correspondingly high and range between 88.8 and 129.4. This region is essentially a high broken plateau of sedimentary and volcanic rocks of the Umkondo system. Both districts are well populated with Natives and in view of the agricultural and pastoral activities, both regions have a fair white population.

The results obtained were as follows:-

(see page 25)

Table III - Umtali District

Parasite	No. of Examinations		Infestations		Percentage Infested	
	Total	Male	Total	Male	Total	Male
<u>S. mansoni</u>	86	64	22	3	1	3.5
<u>S. haematobium</u>	65	49	16	15	5	20.0
						31.2

Table IV - Melsetter District

Parasite	No. of Examinations		Infestations		Percentage Infested	
	Total	Male	Total	Male	Total	Male
<u>S. mansoni</u>	265	134	131	44	19	16.6
<u>S. haematobium</u>	265	134	131	42	14	15.8
					25	14.2
					28	10.4
						21.4

Bikita, Ndanga, Chibi and Victoria Districts

A few observations were made in transit through the districts mentioned above. These districts occupy the south-east corner of the Colony. While apparently well populated with Natives, no true measure of the population could be obtained in the time available. The Europeans in these parts are concerned with cattle--producing, rather than with farming.

The general elevation of the region is about 4,000 feet in the north, falling away in the south to about 2,500 feet.

The area as a whole is well watered and many parts of the Ndanga district are reputed to have a perennial water supply.

Groups of Natives were examined from Reserves in these different areas, but for convenience, the percentages have been estimated on the total number of Natives examined in the four districts. Consequently the results obtained cannot be regarded as an accurate index of the schistosome incidence in any one district.

The results obtained were as follows:-

(see page 27)



Table V

Parasite	No. of Examinations		Infestations		Percentage Infested	
	Total	Male Female	Total	Male Female	Total	Male Female
<u>S. mansoni</u>	119	77 42	- - -	- - -	- - -	- - -
<u>S. haematobium</u>	119	77 42	32 21 11	26.9 27.3 26.2		

Wankie District

The Wankie district occupies the north-west corner of the Colony. On the north it is bounded by the Zambesi River and on the east by the Gwaai River.

With the exception of two or three large rivers, the streams of this district appear to dry up completely early on in the dry season. The average annual rainfall is small, amounting to 22.42 inches, which represents an average of 56.8 rain days per annum.

The rocks of this district belong to the Karoo system and in the Reserve areas are mainly sandstone, shales and coal. Consequently the Reserves are for the most part sandy areas covered with thick bush.

The onset of the rains, with its associated flooding of the rivers, restricted the investigations in this region to some extent. One hundred and sixty-six Indigenous Natives were examined with the following results:-

(see page 29)

Table VI

Parasite	No. of Examinations		Infestations		Percentage Infested	
	Total	Male Female	Total	Male Female	Total	Male Female
<u>S. mansoni</u>	166	77 89	11 10 1	6.6 13.0 1.1		
<u>S. haematobium</u>	166	77 89	36 22 14	21.7 28.6 15.7		

Natives Entering Southern Rhodesia From  
Northern Rhodesia, Nyasaland & Portuguese East Africa

As already mentioned large numbers of Natives enter Southern Rhodesia daily from adjoining territories for the purpose of obtaining work in the mines, farms and households of the Colony. The regulations pertaining to this Native immigration make it necessary for the Native to enter the country through one or other of the frontier stations.

A number of entering Natives were examined at two of these stations, namely, Rasambo and Mt. Darwin - both in the Darwin district. As practically all of these Natives were entering Rhodesia for the first time the examination results serve to indicate to what extent schistosome infestations were being introduced into the Colony from without.

The results obtained were as follows:-

(see pages 31 and 32)



Table VII - Natives from Northern Rhodesia

<u>Parasite</u>	<u>No. of Examinations</u>		<u>Infestations</u>		<u>Percentage Infested</u>	
	<u>Total</u>	<u>Male</u>	<u>Total</u>	<u>Male</u>	<u>Total</u>	<u>Male</u>
<u>S. mansoni</u>	63	52	11	3	2	1
					4.8	3.8
<u>S. haematobium</u>	63	52	11	37	29	8
					58.7	71.2
						72.7

Table VIII - Natives from Nyasaland

<u>Parasite</u>	<u>No. of Examinations</u>		<u>Infestations</u>		<u>Percentage Infested</u>	
	<u>Total</u>	<u>Male</u>	<u>Total</u>	<u>Male</u>	<u>Total</u>	<u>Male</u>
<u>S. mansoni</u>	75	73	2	7	7	-
					9.3	-
<u>S. haematobium</u>	75	73	2	19	19	-
					25.3	-

Table IX - Natives from Portuguese East Africa

Parasite	No. of Examinations		Infestations		Percentage Infested	
	Total	Male	Total	Male	Total	Male
<u>S. mansoni</u>	16	13	3	1	6.3	-
<u>S. haematobium</u>	16	13	7	6	43.8	-

A Mixed Native Community

The foregoing statistics serve to indicate the incidence of schistosome infestations amongst Indigenous Natives on the one hand, and entering Natives on the other. But the extent to which these infestations are brought into the immediate proximity of the White population can be appreciated most readily from the statistics pertaining to a Mixed Native Community of an area with a relatively large number of European inhabitants. Where local conditions favour the development of the schistosome and its transmission to definitive or reservoir hosts, it is obvious that with a high schistosome incidence amongst the Natives, the White population is continually exposed to the risk of infestation. A large number of examinations were carried out on Natives admitted to the Salisbury Native Hospital. This group probably represented a cross section of the Native population of the Colony, in that it contained representatives not only from Southern Rhodesia itself, but also from all the adjoining territories, in particular Northern Rhodesia, Nyasaland and Portuguese East Africa. Furthermore, this group of Natives was drawn from Salisbury and its immediate environs, where conditions favour the completion of the schistosome life-cycle and

represents the extent to which Europeans, particularly European children, are exposed to schistosome invasion.

Table X - The Mixed Native Community

Parasite	No. of Examinations		Infestations		Percentage Infested	
	Total	Male Female	Total	Male Female	Total	Male Female
<u>S. mansoni</u>	758	717 41	131 131	-	17.3 18.3	-
<u>S. haematobium</u>	826	794 32	245 234	11	29.7 29.5	34.4



Non-Europeans

The observations on this section of the community were confined to those cases admitted to the Salisbury Hospital during the period of investigation. A total of 28 cases were examined, but in no instance was evidence of schistosome invasion found.

Europeans

The distribution of the population, together with a number of other factors associated with European civilisation, made it necessary to limit the examinations to patients in the Salisbury Hospital. The majority of the cases examined were adults who had been resident either in Salisbury itself, or in its immediate neighbourhood, for a number of years. In a few cases the occupation of the individual took him into outlying districts from time to time and thus materially increased his chances of acquiring a schistosome infestation.

During the past few years the incidence of S. haematobium infestations amongst the school children of the Colony has been investigated by the Director of the Public Health Laboratory, Salisbury. Up to the end of 1930, samples of urine from 1,247

boys had been examined and terminal-spined eggs found in 108 cases, an incidence of 8.7 per cent. The incidence amongst school-girls appears to be very much less.

The results obtained from the examination of 200 adults were as follows:-

(see page 37)

Table II. - Parasitism

Parasite	No. of Examinations		Infestations	
	Total	Female	Total	Female
<i>S. mansoni</i>	200	135	65	3
<i>S. haematobium</i>	200	135	65	15

Table XI - Europeans

Parasite	No. of Examinations		Infestations		Percentage Infested	
	Total	Male	Total	Male	Total	Male
<u>S. mansoni</u>	200	135	65	3	3	1.5
<u>S. haematobium</u>	200	135	65	10	10	5.0

Species Incidence

As the tables of the preceding section indicate, schistosome infestations occur, with variable frequency, amongst the Indigenous and Non-Indigenous Natives of the Colony, and also amongst the resident Europeans. In order to facilitate the discussion on the species incidence, the percentage incidence of the two parasites is summarised in Table XII.

Table XII

Incidence of S. mansoni and S. haematobium  
amongst different sections of the population of  
Southern Rhodesia

	<u>S. mansoni</u>	<u>S. haematobium</u>
Indigenous Natives of:-	%	%
Sebungwe	1.8	9.6
Darwin	9.2	21.8
Umtali	3.5	20.0
Melsetter	16.6	15.8
Bikita, Ndanga, etc.	-	26.9
Wankie	6.6	21.7
Non-Indigenous Natives from:-		
Northern Rhodesia	4.8	58.7
Nyasaland	9.3	25.3
Portuguese East Africa	6.3	43.8
Mixed Native Community	17.3	29.7
Europeans (adults)	1.5	5.0

The field investigations in the Native Reserves have clearly established the fact that infestations with S. mansoni and S. haematobium occur amongst the Indigenous Natives of Southern Rhodesia.

They have also shown a very striking difference in the relative incidence of the two parasites.

S. haematobium infestations occur with much greater frequency and are more widely distributed throughout the Colony than S. mansoni. It will be seen from Table XII that in one district only, namely Melsetter, did the mansoni infestations predominate, but even in this district the difference is not statistically significant. Elsewhere, the mansoni percentage incidence is definitely lower than the corresponding S. haematobium incidence, ranging between 1.8 and 9.2 per cent.

In only two districts, Melsetter and Sebungwe did the S. haematobium incidence fall below 20.0 per cent.

Sebungwe is a wide tract of country with a low rainfall and streams that flow over sand or solid rock and dry up more or less completely for four or five months each year. Residual pools are set, for the most part, in this sand or solid rock often devoid of marginal vegetation and thereby unsuited to the requirements of fresh-water molluscs. Although numerous pools in different parts of the Sebungwe district were



systematically examined, no specimens of snails were found. Their presence, however, must be presumed in certain parts of the district at least in view of the existence of bilharzial infestations amongst children who had never been beyond the confines of their particular Reserve.

In the Melsetter district on the other hand, where the land is of a more mountainous character, it is probable that the large number of rivers and streams, unsuited to the habits of the 'bilharzia snails', tend to maintain the schistosome incidence at a lower level than is met with in the flatter districts.

In those other districts visited it was always possible to find fresh-water molluscs in sufficient numbers to account for the schistosome incidence of the part. In these areas, S. haematobium was present in from 20 to 26.9 per cent of the Natives. It is of interest to note, however, that in any given district the schistosome incidence may vary widely in different localities, depending on certain environmental factors in the immediate neighbourhood of the different kraals.

During the dry season a large proportion of the rivers and streams of the Colony dry up wholly, or in part, thus restricting very considerably the sources from which the Natives of the kraals are able to obtain

supplies of water sufficient for their daily requirements. It was not uncommonly found for example that at one kraal the Natives obtained their water from a small residual pool situated in an otherwise dried up river or stream bed, whereas at another kraal a few miles further on the river or stream had dried up completely and the Native could obtain water only by digging small pits in the sandy bed of the stream (2 or 3 feet deep and 1 to  $1\frac{1}{2}$  feet across the top) into which water percolated slowly. The remarkable difference in the schistosome incidence prevailing at kraals where this particular difference in water supply exists during the dry season can be best illustrated by certain figures obtained while in the Darwin Reserves.

At one kraal on the Darwin-Rasambo road the Natives obtained water from a large residual pool containing numbers of 'bilharzia snails'. Out of 40 Natives examined, 32 were infested to a greater or less extent with S. haematobium. At another kraal (on the same road) where water was obtained from pits dug in the sandy bed of a stream only 2 out of 35 Natives were found to have haematobium eggs in the urine.

While this matter will be discussed more fully in the sequel, it is evident that considerable

variations exist in the schistosome incidence in different parts of a given district.

### Sex Incidence

Lyle (1883) showed in his account of endemic haematuria amongst the Natives of the south-east coast of Africa that both sexes were affected to more or less the same extent and it was soon realised that the sex incidence of the schistosome infestations was determined by the relative opportunities of the two sexes for coming in contact with infected water.

In the districts visited the Native customs and habits of life rendered the two sexes more or less equally liable to bilharzial infestation. There is perhaps a slightly increasing tendency for males to be more frequently infested than females in view of the fact that the males tend to move further from their kraals than formerly, either in search of work or animal food. In their wanderings they drink indiscriminately from wayside pools and in this way increase their chances of acquiring the infestations.

Tables XIII and XIV shows the sex incidence of the schistosome infestations amongst groups of Natives of all ages from a series of Reserves.

(see page 43)

Table XIII

Sex incidence of the S. mansoni infestations

District	<u>Number of examinations</u>		<u>Infestations</u>		<u>Percentage Infested</u>	
	Male	Female	Male	Female	Male	Female
Sebungwe	119	109	2	2	1.7	1.8
Darwin	104	80	11	6	10.6	7.5
Umtali	64	22	2	1	3.1	4.5
Melsetter	134	131	19	25	14.2	19.1
Bikiti, Ndanga, etc.	77	42	-	-	-	-
Wankie	77	89	10	1	13.0	1.1

Table XIV

Sex incidence of the S. haematobium infestations

District	<u>Number of examinations</u>		<u>Infestations</u>		<u>Percentage Infested</u>	
	Male	Female	Male	Female	Male	Female
Sebungwe	119	109	18	4	15.1	3.7
Darwin	122	80	32	12	26.2	15.0
Umtali	49	16	10	5	20.4	31.2
Melsetter	134	131	14	28	10.4	21.4
Bikiti, Ndanga, etc.	77	42	21	11	27.3	26.2
Wankie	77	89	22	14	28.6	15.7

In three districts, Sebungwe, Melsetter and Wankie, the percentage incidence of the schistosome infestations in the two sexes is statistically significant.

In Sebungwe, males were infested with S. haematobium about five times more frequently than females, while in Melsetter, females infested with S. haematobium were about twice as common as males. In the Wankie area, both mansoni and haematobium infestations were more frequently present in males. In other districts the differences in the percentage infestations are not statistically significant.

It need only be said that in those areas in which one sex was more heavily infested than the other, the difference was entirely due to one coming more in contact with infected pools than the other.

#### Non-Indigenous Natives

Schistosome infestations were commonly met with amongst Natives entering Southern Rhodesia from north of the Zambesi River. S. mansoni and S. haematobium occurred, but, as in the case of the Indigenous Native, haematobium infestations predominated.

It was found (see Table XII) that the incidence of S. mansoni amongst Northern Natives did not differ significantly from that prevailing amongst the Natives of the Colony. The intensity of the infestations were practically alike in the two groups of Natives.



Haematobium infestations, on the other hand, occurred with considerably greater frequency amongst the entering Natives, particularly in those Natives coming from Northern Rhodesia and Portuguese East Africa. As these examinations were carried out at different times on different batches of Natives the results probably represent fairly accurately the general incidence of the two parasites in those territories to the north and east of Southern Rhodesia.

Post-mortem examinations carried out at the Salisbury Hospital showed that in addition to the greater frequency of urinary schistosomiasis amongst Northern Natives the infestations were on the whole much heavier than was generally met with amongst the Indigenous Natives.

#### A Mixed Native Community

The results of a large number of examinations carried out on the Mixed Native Community of the Salisbury district showed a closer approximation of the relative incidence of S. mansoni and S. haematobium than was met with in the Reserves or amongst entering Natives. While the percentage incidence of the two parasites is high it must not be taken to indicate an environment particularly well adapted to their spread. In a mixed

community of this type the general incidence is determined largely by the incidence prevailing in the various districts from which the different Natives originally came. On the other hand, since local conditions in the Salisbury area allow of the completion of the schistosome life-cycle the extent to which Natives of this region are parasitised with the schistosomes is a matter of considerable importance from the view point of preventive medicine.

#### Europeans

The work of Dr. Orpen, Director of the Public Health Laboratory, Salisbury, has been referred to already. He has shown that haematobium infestations are not infrequently met with amongst European school-boys. In his series 8.7% of the boys were infested. The existence of S. mansoni infestations was not ascertained.

The present investigation has shown that infestations with S. mansoni and S. haematobium are met with amongst the adult Europeans of the Colony and as in the case of the Natives, haematobium is the dominant infestation. Males are very much more frequently infested than females and in the present series, of 65 adult females no evidence of schistosome infestation could be found on microscopical examination.

Here again, the relative incidence of the infestations in the two sexes is entirely due to the greater opportunities that the male has of acquiring the parasite, particularly during boyhood and early adult life when camping parties and the practice of bathing in any attractive pool is a popular past-time.

### Intensity of the Infestations

The conclusions regarding the intensity of the infestations amongst the Natives are based partly on the clinical experience of medical officers of the Colony and the clinical examination of Natives in the Salisbury Hospital, but chiefly on the laboratory examination of faeces and urine and on the findings at a series of autopsies.

### Clinical Evidence.

It may be said at once that gross clinical manifestations of intestinal schistosomiasis are very rarely met with in Southern Rhodesia. Only one case of S. mansoni infestation, accompanied by dysenteric symptoms, was encountered in the course of the investigation. The patient was a Native-boy about 7 years old from the Umtali district.

Urinary schistosomiasis as manifested by a terminal haematuria is met with in Natives and Europeans

but much less frequently than the laboratory findings lead one to anticipate. It must, of course, be remembered that the Native tends to be reticent on such matters and the European is still inclined to treat the matter lightly.

A few cases of ascites associated with hepatic cirrhosis of bilharzial (S. mansoni) origin, are stated to be admitted to the Native Hospitals each year. Two cases of this nature were admitted to the Salisbury Hospital while the investigations were in progress, but in neither case was an autopsy performed. Clinical evidence by itself gives the impression that schistosome infestations play a relatively minor rôle as a disease producing factor in the Colony, but routine laboratory investigation, together with an examination of post-mortem material, have shown this view to be erroneous.

#### Laboratory Evidence

While it is realised that the number of schistosome eggs found in a given sample of urine cannot be regarded as an accurate index of the intensity of the infestation, in recording the results of the microscopical examinations the ease with which the eggs could be demonstrated in the specimen was indicated by the signs +, ++, +++.

A single plus sign indicated that not more than about 3 eggs were found in the specimen, while the triple



plus sign showed that one or more eggs were present in almost every microscopic field. The double plus sign indicated intermediate stages.

It was frequently noted that daily specimens from the same individual showed considerable variation in the number of eggs present. In the case of S. haematobium infestations this variation applied not only to single samples of urine, but also to 24 hour specimens, suggesting a diurnal variation in the egg-output of the infesting worms.

A general impression, however, can be formed of the intensity of the urinary infestations from this method of recording the microscopical findings. For example, in a series of 227 urines from a mixed group of Natives the following results were recorded:-

130 +,      50 ++,      47 +++.

Expressed as a percentage, light or very light infestations constituted 57.27 per cent of the series, moderate infestations 22.03 per cent, while microscopically heavy infestations constituted the remaining 20.70 per cent.

The amount of blood in a given sample of bilharzial urine also varied from day to day and could not, therefore, be relied on as an accurate index of the character of the infestation or the extent of the pathological changes present in the urinary tract.



Other microscopical characters of the urine were also too variable to be of value as an index of the intensity of the infestations.

Mansoni infestations were mainly light in character. The number of eggs found in a given sample of faeces was generally small. From time to time, cases occurred with numerous eggs in the stools, but even in such cases signs or symptoms of intestinal schistosomiasis were lacking, at the time of the examination. It must, of course, be remembered, that the bulk of the stool, the part of the stool selected for examination, the activity of the female worms and a number of other factors combine to make the number of eggs in a given sample of faeces an even more unreliable index of the intensity of the infestation than in the urinary variety of the disease.

With due regard to all these variable factors, the laboratory examinations show that the majority of the infestations with both S. mansoni and S. haematobium were essentially light in character. Heavy haematobium infestations were met with in about 20 per cent of positive cases (amongst Natives) while heavy mansoni infestations were very much less common.

The expression 'light infestation' refers here only to the number of parasites present in the host and is

not to be taken as an index of the gravity of the pathological changes present in such cases.

These simple laboratory tests serve to show that schistosome infestations of the urinary and intestinal tracts are much more common amongst the Natives of the Colony than was suspected hitherto. Apart altogether from the intensity of the infestations the incidence alone is a matter of considerable importance from the viewpoint of preventive medicine. When in addition the close association between parasite and host is considered, it is apparent that even a few schistosomes are capable of producing significant pathological changes in the tissues of the host and, therefore, it is highly probable that many cases giving only laboratory evidence of schistosome invasion have already suffered considerable damage both locally in the organs directly invaded and also in respect of their power of resistance to intercurrent infections, particularly those of a bacterial character. The pathological lesions discussed in the following section give a fresh significance to light infestations which are too apt to be regarded as of epidemiological importance only in view of the absence of well-marked clinical manifestations.



### Pathological Evidence

The postmortem examinations were carried out not with the idea of making a detailed study of schistosomiasis as it occurs in Southern Rhodesia, but rather to ascertain the extent of the tissue damage present in those sub-clinical cases of schistosomiasis which are so common amongst the Natives of the Colony.

A total of 12 autopsies were carried out on Natives who had given laboratory evidence of schistosomiasis but in whom clinical evidence of the disease was not manifest at the time of their admission to hospital. In the majority of cases death was due to lobar or broncho-pneumonia, in other cases to enteric fever. Of these 12 cases, 7 harboured S. haematobium, 2 S. mansoni, and 3 showed a double infestation. The laboratory findings may be summarised as follows:-

Urinary schistosomiasis	Light infestation	(+)	5 cases
	Moderate	" (+)	1 case
	Heavy	" (##)	1 case
Intestinal	"	- Light infestation	(+) 2 cases
Double infestations			
<u>S. haematobium</u>	- Light infestation	(+)	2 cases
<u>S. mansoni</u>	- " "	(+)	
<u>S. haematobium</u>	- Moderate	" (+)	1 case
<u>S. mansoni</u>	- Light	" (+)	

It is evident, therefore, that from the laboratory

standpoint all the cases autopsied, with one exception, would be classed as light or as moderate infestations, and as already indicated, their clinical condition presented none of the features of active schistosomiasis. Accordingly, considerable interest attaches to the nature of the schistosome lesions found in these cases.

### Macroscopic Appearances

#### Urinary Schistosomiasis:

The 'sandy patch' constituted the main lesion in the urinary bladders of four of the five cases in whom light infestations had been recorded. The patch generally occurred in the region of the trigone and varied in size from a few millimetres to several centimetres in greatest diameter and in most cases there tended to be three or four small discrete patches which presumably would have coalesced eventually to form the more extensive lesions met with in heavy infestations.

In one case five or six minute yellowish tubercles were noted on the posterior wall of the bladder. No erosion of the mucous membrane had taken place but injected vessels could be seen all over the surface. This case would seem to have been infested a comparatively short time prior to autopsy. In those cases in whom erosion of the vesical mucous membrane had occurred,



the bladder was invariably thicker than normal, but there was no macroscopical evidence of ureteric involvement or involvement of prostate or seminal vesicles.

The only example of a case in whom a moderately heavy infestation was recorded, showed at autopsy a much thickened bladder wall, extensive erosion of the mucous membrane, together with a small sessile papilloma situated low down on the posterior wall. The lower ends of both ureters were involved as evidenced by thickening of the ureteric walls and loss of lining epithelium.

Similar lesions were found in the case classed as "heavily infested". In addition to a small pea-like papilloma, several minute tubercles of a similar nature were scattered over the postero-lateral walls and the mucous membrane where erosion had not occurred was rugose and intensely congested. Both ureters showed patchy erosions at various points in their course.

Macroscopic lesions were not found in the liver in this series of cases while in the lung, the only lesions noted were those associated with the terminal lobar or broncho-pneumonia.

#### Intestinal Schistosomiasis:

Although living schistosomes were recovered either



from the mesenteric veins or from the liver in the two cases of intestinal schistosomiasis that came to autopsy, no macroscopic lesions were found in the large intestine.

In one case the liver was slightly, but definitely, enlarged and showed an increased amount of connective tissue in the periportal areas. In the other case, the liver presented no macroscopic lesions.

#### Mixed Infestation:

While patchy erosion of the mucous membrane and thickening of the wall of the urinary bladder was found in both cases, no intestinal lesions were noted. A mild degree of hepatic cirrhosis (predominately periportal in distribution) was present in the two cases.

#### Microscopic Appearances

##### Urinary Schistosomiasis:

Urinary Bladder: In the lightly infested group of cases the lesions ranged from early pseudo-tubercles in the submucous tissue to extensive erosion of the mucous membrane and fibrosis of the bladder wall.

The lesion which characterised this group consisted of a much thickened submucosal layer containing large numbers of eggs and devoid of covering mucous membrane.

The submucosal tissue was composed of connective tissue of varying degrees of maturity and in addition to ~~the~~ accumulations of eggs, showed extensive infiltration with mononuclear cells and fibroblasts. In some cases recently formed pseudo-tubercles were noted in proximity to the more advanced submucosal lesions and were characterised by accumulations of eosinophiles and the occurrence of multi-nucleated giant cells in relation to a group of recently deposited eggs. The vascularity of the submucosal tissue varied considerably and was presumably determined by the maturity of the connective tissue of the part. In two cases the free surface of the sandy patch was open and ragged in appearance and extensively infiltrated with neutrophile polymorphs suggestive of bacterial invasion.

It was noted that residual portions of transitional epithelium not infrequently persisted on the surface of the sandy patch, but in such cases apparently represented the remains of tubular epithelial downgrowths which had developed at an earlier stage in the disease process.

The transitional epithelium in the immediate neighbourhood of a sandy patch frequently showed a tendency to abnormal activity on the part of the basal cells with the result that a heaping up of epithelium occurred and in some cases folding of the epithelium ensued, giving an appearance of tubular downgrowths which

however left the basement membrane intact.

The submucosal tissue in relation to epithelial changes of this nature was usually extensively infiltrated with cells of the mononuclear series, together with numbers of proliferating fibroblasts and presented an appearance of vascular congestion.

In all cases the muscular layer showed a well established degree of interstitial myositis not only in relation to overlying bilharzial lesions, but also in parts otherwise normal in appearance. Eggs were not demonstrated in the muscular layer in this group of cases.

Ureters: In one case only was evidence of ureteric involvement demonstrated. A few eggs were present deeply placed in the muscular layer surrounded by old connective tissue and not associated with any lesion of the lining epithelium.

Prostate and Seminal Vesicles: No lesions were found in these organs.

Liver: The hepatic lesions observed were of minor importance. Very occasionally an egg could be demonstrated in the liver substance surrounded by a collection of mononuclear cells through which ran a number of connective tissue fibres.

A coarse pigment was sometimes present in scanty amounts within the Küpffer cells.

The urinary bladder in those cases typifying moderately heavy and heavy infestations presented lesions of an essentially similar character to those already described, the difference being largely one of degree. In addition to a more extensive involvement of the mucous membrane, submucous and muscular tissues, these cases presented the additional feature of papilloma formation.

The papillomata examined were found to consist of a large nodule of loose connective tissue heavily charged with eggs, extensively infiltrated with cells but relatively avascular. The surface of the nodule was ragged and devoid of covering epithelium, although the remains of a previously hypertrophied epithelial layer could be demonstrated in the form of residual portions of tubular downgrowths. While the cells of the deeper parts of the papilloma were mainly mononuclear with a sprinkling of eosinophiles and an occasional giant cell in relation to recently deposited eggs, large numbers of neutrophile polymorphs were present in the surface layer where an ulcerative process was obviously in progress.

In both cases there was abundant evidence of ureteric involvement. Although large numbers of eggs could not be demonstrated in the walls, ~~of~~ the lining epithelium,



in places, presented evidence of over-proliferation in the form of thickening and folding of the mucous membrane. In places erosion of the covering epithelium had occurred with an associated fibrosis of the subjacent tissues.

Both cases showed numerous egg deposits in the prostate and seminal vesicles, together with widespread fibrosis and epithelial proliferation.

Hepatic lesions were difficult to demonstrate and consisted of small focal accumulations of mononuclear cells in relation to one or more eggs. Coarse pigment could be demonstrated in both cases.

#### Intestinal Schistosomiasis:

Descending Colon: As the large intestine presented no macroscopic lesions the portions of colon taken for histological examination were usually selected at random from the descending section of the large gut. Where a schistosome was visible in a vein in close proximity to the gut the overlying section of bowel was selected.

In the first case examined a few calcified eggs were seen scattered throughout the submucosa which showed a slight excess of connective tissue in relation to the eggs together with a mild degree of infiltration with mononuclear cells. The mucous membrane was intact and presented no structural abnormalities. The muscular and



serous coats were also normal in appearance.

In the second case although the eggs were scanty they had apparently been more recently deposited.

A few were present in the mucous layer where they had occasioned considerable congestion and cell-infiltration but no ulceration was noted. Eggs were also present in the submucosa where similar reactions had occurred. The muscular and serous coats were again normal in appearance.

Liver: The chief interest of hepatic lesions lies in the fact that in both cases they were out of all proportion to the amount of intestinal damage found.

In the case in which only a few calcified eggs were found in the submucosa, the liver sections showed an extensive periportal fibrosis, involving even the smallest of the portal tracts. The connective tissue was relatively avascular and acellular and contained few eggs. Considerable quantities of coarse pigment were distributed throughout the liver, located mainly in enlarged Küpffer cells.

As already stated, the fibrosis had produced changes in the macroscopic appearance of the liver.

In the second case a mild degree of periportal fibrosis was evident but in this case the large numbers of infiltrating cells indicated a more recently formed connective tissue. In addition a few cellular foci were noted in the liver substance in relation to impacted schistosome eggs. Coarse pigment was again abundant.

As the cases of double infestation presented no additional features of interest to the present discussion they will not be discussed further.

Neoplastic Degeneration: Reference has already been made to the active proliferation of vesical and ureteric epithelium in relation to egg deposits but in the above series of cases no evidence of the onset of malignant changes was found. An interesting example of precancerous degeneration occurring in a bilharzial bladder will be referred to in a later section. The case is mentioned at this stage merely to complete the account of the types of lesions met with during the investigation. As the Native was dead when admitted to hospital it was not possible to group him according to the urinary findings.

Recovery of Adult Worms: In most cases adult schistosomes were looked for in relation to the affected organs but it was rarely possible to recover

more than five or six parasites from a given case. It was not always possible to carry out an exhaustive search for parasites but the scanty numbers recovered suggest that in the great majority of cases of schistosomiasis in Southern Rhodesia, schistosomes are present in the tissues in relatively small numbers.

The present series of autopsies may be regarded as exemplifying the pathological features of schistosomiasis (urinary and intestinal) as it is most commonly met with amongst the Native population of Southern Rhodesia.

Urinary schistosomiasis is characterized by the formation of the sandy patch and sessile papillomata together with extensive interstitial apoptosis. It is also common to find bilateral lesions in the ureters, prostate and seminal vesicles. The histological changes met with in the liver are of minor importance.

In the intestinal form of schistosomiasis, gut lesions are usually insignificant but periporal fibrosis of varying degrees of intensity can usually be demonstrated microscopically if not macroscopically in the liver.

Conclusions

Clinical study together with simple microscopic examination of urine and faeces was found to give an imperfect impression of the amount of tissue damage sustained by the host in the presence of schistosome invasion. Only by post-mortem examination was it possible to determine the significance to be attached to the presence of schistosome eggs in the urine or faeces of individuals in apparent good health.

The present series of autopsies may be regarded as exemplifying the pathological features of schistosomiasis (urinary and intestinal) as it is most commonly met with amongst the Native population of Southern Rhodesia.

Urinary schistosomiasis is characterised by the formation of the sandy patch and sessile papillomata together with extensive interstitial myositis. It is also common to find bilharzial lesions in the ureters, prostate and seminal vesicles. The histological changes met with in the liver are of minor importance.

In the intestinal form of schistosomiasis, gut lesions are remarkably insignificant but periportal fibrosis of varying degrees of intensity can usually be demonstrated microscopically if not macroscopically in the liver



of such cases.

In all cases the number of schistosomes recovered at autopsy was remarkably small in comparison with the pathological changes. It is evident that the amount of tissue damage sustained by the host is much greater than can be accounted for by the mere mechanical presence of the parasite or its eggs.

The toxic products of the worm and the miracidial secretions are manifestly capable of producing tissue changes out of all proportion to the number of invading worms. In doing so, not only do they impair the functional efficiency of various organs, but render secondary bacterial invasion of the lesion an all too common complication. Furthermore, the diffusion of toxic substances into the blood stream may have even more far reaching effects on the mechanism of blood production and general immunity response, an aspect of the problem to be referred to later.

The main conclusion arrived at from these laboratory studies is that in most cases of schistosomiasis amongst the Native races of Southern Rhodesia the number of invading parasites is, generally, small and although there may be little or no clinical evidence of schistosome invasion, extensive and damaging pathological changes have probably occurred.

While in vesical schistosomiasis these changes were





The Intermediate Hosts of the  
Mammalian Schistosomes of  
Southern Rhodesia  
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In the determination of the intermediate hosts of the mammalian schistosomes of Southern Rhodesia animal experimentation was employed whenever possible.

When a batch of snails had been collected they were placed in large test tubes (three or four snails to a tube) containing fresh, clean water and cercariae looked for at intervals during the next 24 or 48 hours. When cercariae were observed in a given tube the molluscs were placed in separate tubes and thus the cercaria-producing snails were separated off from the others. When it was decided from a microscopic examination that the mollusc was shedding mammalian schistosome cercariae, a concentrated aqueous suspension of active cercariae was prepared.

At first the method of concentration consisted in gentle centrifugation of the contents of the test tube and rapid decantation of the supernatant fluid leaving about 1 c.c. of fluid in the centrifuge tube. While considerable concentration could be obtained by this technique,

it was found that the centrifugal force caused a considerable proportion of the cercariae to adhere firmly to the sides of the tube. It also induced premature shedding of the tail and as low speeds had necessarily to be employed, a certain number of vigorous cercariae rose in the fluid so rapidly after cessation of centrifugation that they were invariably poured off during the decanting process.

Later a filtration technique was evolved which eliminated the necessity for centrifugation. In this method a 2" (or larger) filter funnel is taken, a piece of filter paper placed in the funnel and moistened and the lower end of the stem plugged with plasticine. A hole is made through the plasticine with a dissecting needle and adjusted by experimentation until it is sufficiently large to deliver 20 - 25 c.c. of water in about 4 minutes. This speed was found to be the optimum filtration speed for the concentrating process. Water containing cercariae is then poured into the funnel which has been placed in a measuring cylinder of convenient size. Before all the water has drained into the cylinder the sides of the filter paper are washed down with a gentle stream of water from a wash - bottle. In this way the cercariae are concentrated in the apex of the funnel. Filtration is stopped by

withdrawing the funnel from the cylinder and placing the finger over the lower end of the stem, or by leaving the funnel in position and filling the cylinder to the brim. The water in the funnel with its suspension of cercariae is withdrawn with a small pipette and placed in a suitable receptacle. In this way many hundreds of cercariae can be concentrated in a very small volume of water. There is no tendency for the cercariae to pass through the filter paper and they can be readily washed down from the sides of the funnel.

In administering cercariae to an experimental animal advantage was taken of the fact that the schistosome larvae penetrate the soft mucous membrane of the lips and mouth with greater ease than they penetrate the skin. By means of a dropping pipette cercarial fluid was applied to the mucous membrane of the lips and mouth, or squirted against the buccal mucous membrane in order to stimulate the adhesion reflex of the cercariae.

Some five to ten minutes after the application of the cercariae-containing fluid the animals invariably showed signs of oral irritation. The lips would twitch at first slightly, later more vigorously and spasmodically and the animal would

often make violent efforts to get at its mouth with its fore-paws. This irritation would gradually pass off in another ten minutes or quarter of an hour and the animal became quiescent. No labial or buccal lesions were ever found to follow the application of concentrated cercarial suspensions. To ensure adequate cercarial penetration the animal was generally restrained for about 30 minutes after exposure to the cercariae and in several instances the animals received more than one exposure to the cercarial fluid.

Four to five weeks after the date of exposure microscopical examination of the faeces of the animal was carried out from time to time with a view to obtaining some clue to the success of the experiment.

The animals used in this series of experiments were guinea-pigs, rabbits, sheep and monkeys. In the case of the smaller animals (guinea-pigs and rabbits) the faeces were never found to afford evidence of successful invasion, but schistosome eggs could always be demonstrated readily enough in positive experiments on sheep and monkeys.

An animal was never killed less than two months after the date of exposure to cercariae.

In attempting to ascertain the intermediate hosts of the human schistosomes, the cercariae employed were obtained from naturally infected molluscs in the case



of S. haematobium and from experimentally infected molluscs in the case of S. mansoni.

The results of these experiments showed that the common intermediate host of S. haematobium in Southern Rhodesia is Physopsis globosa, while the common intermediate host of S. mansoni is Planorbis pfeifferi. (See Plates I, II and III).

The cercariae employed to infect the rabbit in which S. haematobium was reared, were obtained from a batch of Physopsis snails collected from the Umfuri River, near Mt. Darwin. The only other laboratory animal exposed to these cercariae was the guinea-pig, but for some reason, infection failed to take place.

S. mansoni was reared in the small grey monkey (Cercopithecus pygerethrus) of Southern Rhodesia from cercariae obtained from experimentally infected snails.

The ease with which this infection was brought about and the fact that the infected monkey continues to pass eggs containing viable miracidia six months from the date of infection, suggests that the monkey is a potential reservoir host of S. mansoni in Southern Rhodesia. No case of natural infestation was found but it is of interest to note that Cameron (1928) recorded cases of natural infestation of Cercopithecus



Plate I

Physopsis globosa (Morel). The intermediate host of S. haematobium and S. matthei in Southern Rhodesia. (Natural size).

Plate II

Specimens of Physopsis globosa  
from various parts of Southern  
Rhodesia.



Plate II

Figs. 1 & 2. - Specimens of Physopsis globosa  
collected in various parts of Southern  
Rhodesia. (Natural size).

The intermediate host of S. muriei in  
Southern Rhodesia. (Natural size).

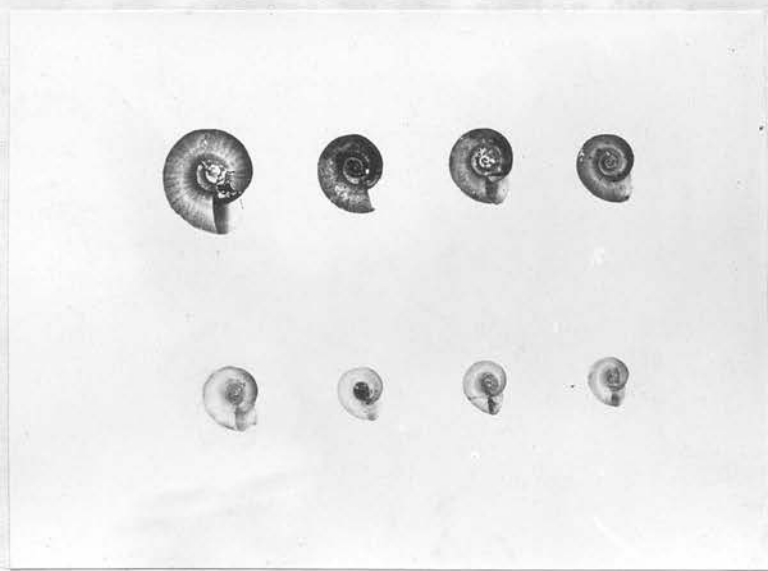
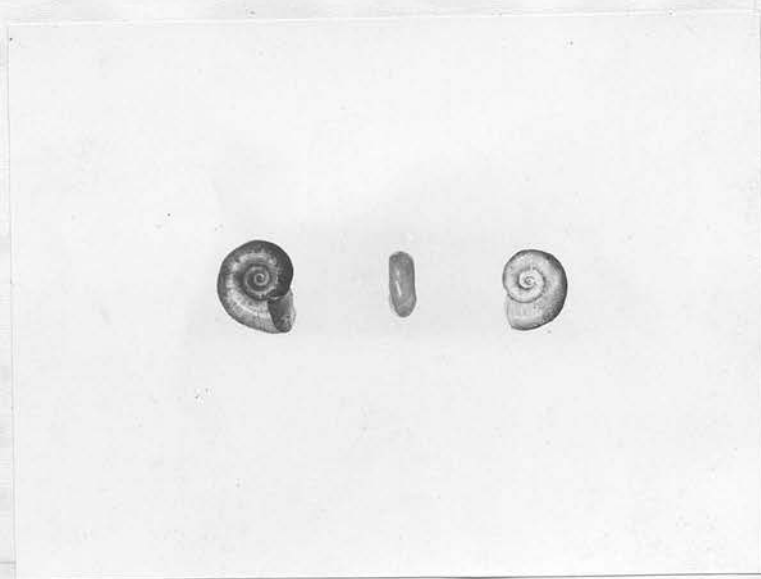


Plate III

Figs. 1 & 2. - Planorbis pfeifferi Krs.  
The intermediate host of S. mansoni in  
Southern Rhodesia. (Natural size).

sabaeus (West African Green Monkey) with S. mansonii on the island of St. Kitts.

Bionomics of Physopsis globosa and Planorbis pfeifferi

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The study of the fresh-water mollusca of Southern Rhodesia was begun in the month of May, immediately after the cessation of the annual rains and was continued until February of the following year. The hot rainy season extends on the average from November to April in most parts of Rhodesia, while the remainder of the year is occupied by the cooler dry season, consequently it was just possible, in the time available, to observe the snails under the seasonal variations of the Colony. During the months of May and June, a number of streams and rivers and a few marshes were searched for molluscs, but only a very few specimens found. This lack of success was partly due to lack of experience in the appearances of snail breeding grounds, but was mainly due to another reason to be discussed later. From July until September or October molluscs of various genera were found in much greater numbers.

Physopsis globosa is much commoner in Southern Rhodesia than Planorbis pfeifferi but the bionomics of the two molluscs have much in common.



These snails are found in relation to deep, still pools in the course of a river or stream. The depth of the pool does not appear to be a matter of importance. The important factors being an adequate food supply and a reasonable amount of shade. The type of pool best adapted to the needs of the molluscs under consideration are typified in Plates IV, V and VI.

The pool is still and deep, as already mentioned; the surface is covered to a greater or less extent with the broad heart-shaped leaves of lotus plants, while the bottom of the pool consists of dark slimy material constituted largely by decaying vegetable matter. The molluscs are found in greatest numbers adhering to the undersurface of the lotus leaves which frequently have a somewhat ragged appearance as a result of the activities of the molluscs.

While working in the Darwin area, P. globosa was repeatedly found in pools devoid of lotus plants. They were found, for example, crawling over the bottom of some shallow, sandy bottomed pool where they appeared to exist on whatever decaying vegetable material it contained. (See Plate VII). At other times they were found in stony or rocky pools where the overhanging ledges provided shade and the algal growths apparently supplied a sufficiency of food. (Plate VIII). Some of these rocky pools frequently contained surprisingly large numbers



Plate IV

A pool from which numerous Physopsis globosa were obtained.



Plate V

A pool near Rasambo in which *Physopsis*,  
*Planorbis* and *Lymnaea* were found.



# Plate VI

A pool from which Physopsis globosa was obtained.

of snails. It is noteworthy that in the Sebungwe area where rocky or sandy pools occurred with greatest frequency, molluscs were not found. It was noted, however, that the Sebungwe pools were for the most part devoid of the marginal vegetation which characterised the pools of the Darwin district and appeared to contain little in the way of decaying organic material.

Planorbis pfeifferi was most often found in relation to the lotus covered pools, but it appeared that they also were capable of existing in pools with a different type of vegetation. On the Umfuri River, near Mt. Darwin, a large pool was found containing large numbers of this mollusc. The pool was deep and stagnant. A small-leaved bushy water weed, (Naias interrupta), grew in considerable profusion down one side of the pool just under the surface of the water and in this weed large numbers of Planorbis were found. It is of interest to note that only a few Physopsis were found in this pool and those that were present fed not on the bushy weed, but on vegetable debris present in the pool.

A green alga which was identified as Chara capensis grew in close association with Naias interrupta and probably constituted an important food factor so far as Planorbis was concerned.



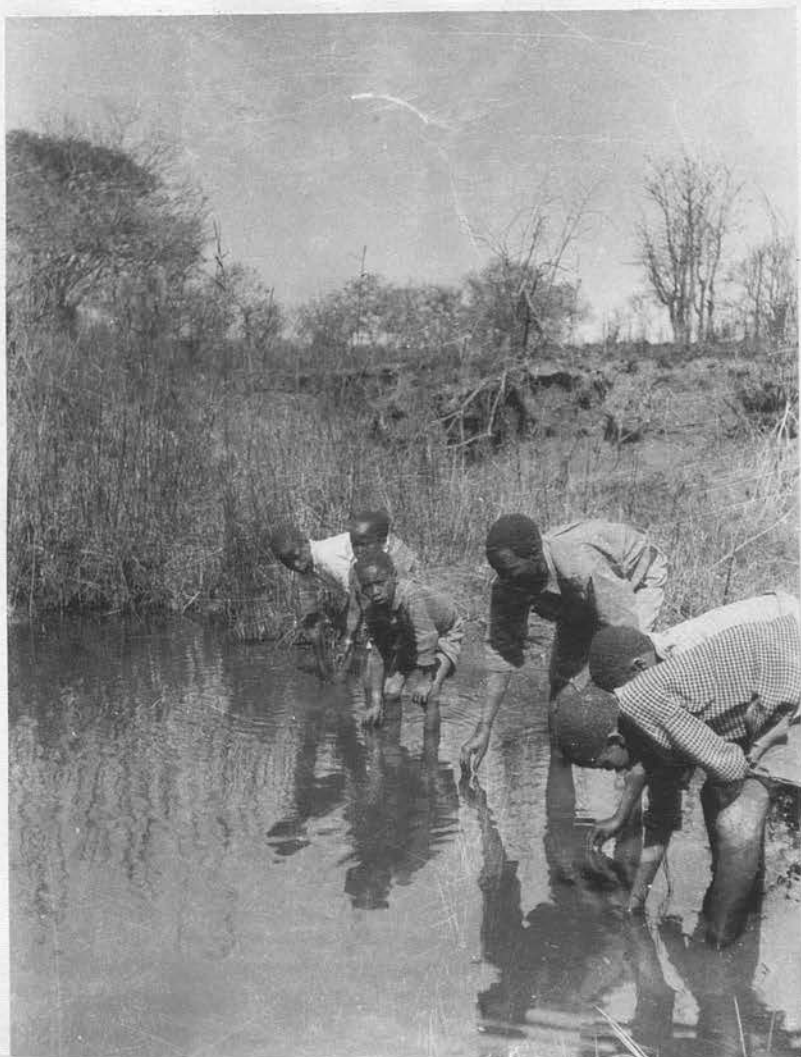


Plate VII

A sandy-bottomed pool devoid of lotus plants but containing numbers of Physopsis globosa.

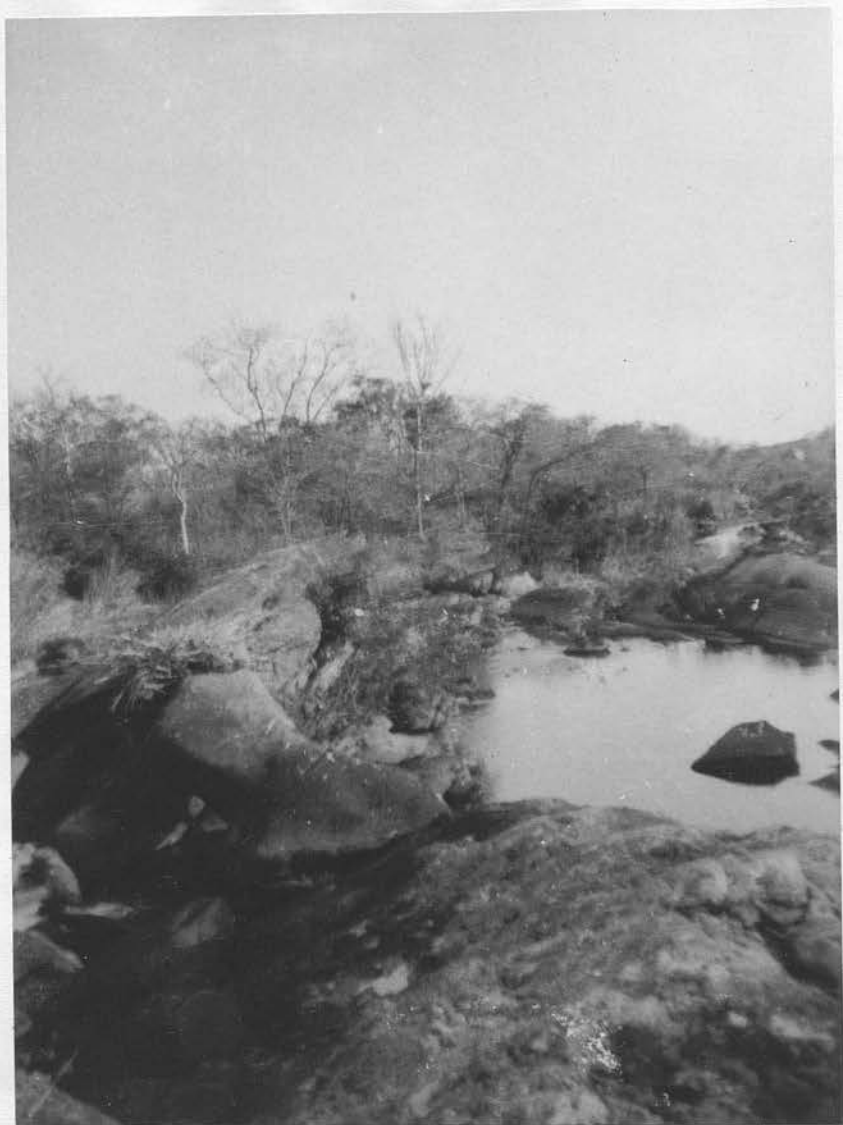


Plate VIII

A rock bound pool in which a few Physopsis globosa were found.

The snails are also frequently seen migrating up or down the long stem of a lotus plant or it may be climbing the algal covered stem of a reed. In a number of instances the first clue to the presence of molluscs in a given pool was the discovery of snail egg-nests. These nests consist of small accumulations of gelatinous material in which numbers of spherical eggs are embedded. The configuration of the nest varies with the molluscan genus, while the size varies to some extent with the maturity of the adults.

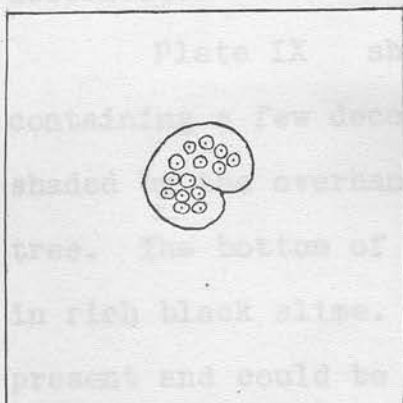
The egg-nests of Physopsis globosa (see Plate VIIIa, fig. 1) are rendered somewhat kidney-shaped in outline on account of a small indentation on one side of the gelatinous mass. Seen from the side, the mass is gently curved with a maximum depth of 1 to 2 mm. An average size is 8 x 5 mm.

The ovum appears as a minute speck embedded in a spherical mass of brownish pigmented material which measures about 1 mm. in diameter. The pigmented eggs give a brownish appearance to the nest as a whole.

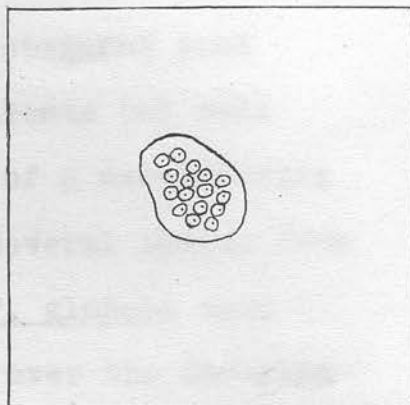
The egg-nests of Planorbis pfeifferi (see Plate VIIIa, fig. 2) are irregularly circular in outline, without the characteristic indentation of the egg-nests of Physopsis globosa. An average size was found to be 6 x 8 mm. The egg of Planorbis is also pigmented.

Physopsis globosa was also found in relation to

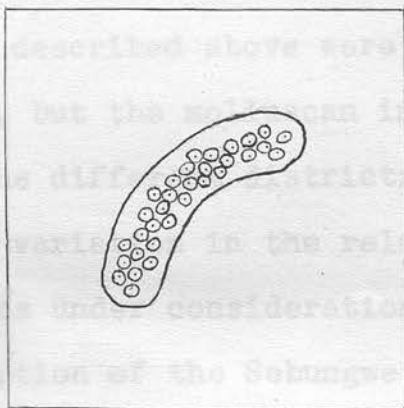
pools of a different character from that already described.



1.



2.



3.

Plate VIII a.

Fig. 1. Egg-nest of Physopsis globosa.

Fig. 2. Egg-nest of Planorbis pfeifferi.

Fig. 3. Egg-nest of Lymnaea natalensis.

pools of a different character from that already described.

Plate IX shows a shallow stagnant pool containing a few decomposed lotus plants but well shaded by the overhanging branches of a neighbouring tree. The bottom of the pool was several inches deep in rich black slime. A number of P. globosa were present and could be seen crawling over the decaying twigs and bits of reed or grass sticking in the slimy mud.

Fresh-water pools presenting characteristics such as have been described above were found in all districts visited, but the molluscan incidence varied considerably in the different districts. There was also a remarkable variation in the relative incidence of the two molluscs under consideration.

With the exception of the Sebungwe and Wankie districts, Physopsis globosa was found in all the Reserves visited. Furthermore, the distribution of the mollusc in a given district was not restricted to a single pool, but could usually be found in various parts of the same district, suggesting a fairly uniform distribution. More extensive sampling of the districts, however, would be necessary before reaching a conclusion on this point.





Plate IX

A shady pool containing a few decomposed lotus plants and numerous Physopsis globosa.

The localities in which Physopsis globosa was found are as follows:-

Darwin district:

Mazarabani Reserve  
Chiswiti           "  
Kandeya           "  
Umfuri River (near Mt. Darwin)

Mazoe           "

Salisbury       "

Gwibi River  
Makabusi River  
Goromonzi Reserve

Umtali           "

Melsetter       "

Chibi           "

}  
}  
}       Unnamed pools  
}

Planorbis pfeifferi had not only a more restricted distribution in the Colony as a whole but it also appeared to have a limited distribution in any of the districts in which it was found. Planorbis was found in the following localities:

Darwin district:   Umfuri River

Mazoe           "       Mazoe Dam  
                          Citrus Estate

Salisbury       "       Goromonzi Reserve

Wankie           "       Deka River

Chibi           "

Other fresh-water Molluscs in  
Southern Rhodesia  
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In addition to the two molluscs discussed above,  
others were found in the course of the investigation.

These were:-

1. Physopsis africana (?) (Krs.)
2. Bulinus natalensis (Krs.) var. ?
3. Bulinus tropicus (Krs.)
4. Lymnaea natalensis (Krs.)
5. Lymnaea caillaudi (Bgt.) syn. L. dakaensis (Stur.)
6. Melanoides tuberculata (Mull.)

Physopsis africana: Some doubt exists regarding  
the identity of certain of the Physopsis spp. found.  
A few approximated closely to P. africana but were not  
entirely true to the British Museum type species.

These doubtful specimens have not been photographed.

Physopsis africana if present in Southern Rhodesia  
has probably a very restricted distribution.

Lymnaea natalensis (see Plate X) on the other hand  
is widely distributed throughout the Colony. It is  
found under conditions exactly similar to those described  
for Physopsis globosa and was frequently found in  
association with the latter. Plate XI illustrates a



Plate X.

Lymnaea natalensis (Krs.)  
(Natural size).

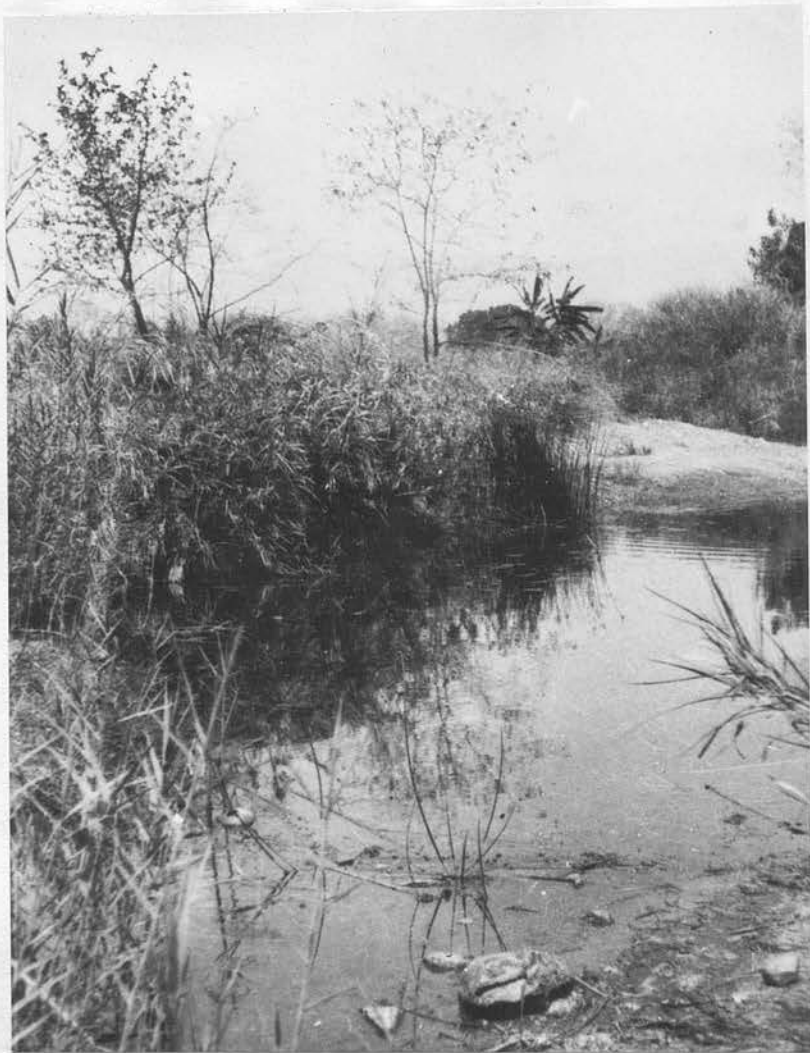


Plate XI

A pool in the Mzarabane Reserve (Darwin District) which contained large numbers of Lymnaea natalensis.



pool heavily charged with L. natalensis. No other snails were present. The pool was devoid of lotus plants, the bottom was sandy and the whole pool unshaded. Numerous snail clusters can be seen on the surface of a plank in the foreground. L. natalensis was also found in slimy, reeded, stagnant pools where apparently *Physopsis* and *Planorbis* were unable to survive. The egg-nests of Lymnaea natalensis are very different in appearance from those of *Physopsis* or *Planorbis*. They consist of elongated rounded masses of a clear gelatinous substance, containing numbers of small, spherical; delicately-pigmented eggs (see Plate VIIIa, fig. 3). This gelatinous mass may be 2 or 3 mm. thick and as much as 20 or more mm. long.

Lymnaea caillaudi (Plate XII) was found on a farm near Salisbury. The snails were present in large numbers in a watering trough for cattle.

Bulinus tropicus (Plate XIII) was found in large numbers in the Makabusi River, near Salisbury, under the leaves of the lotus plants which grew freely in the various pools in the course of the stream. Plate XIV shows a portion of a small tributary of the Makabusi River almost wholly covered with lotus leaves on which large numbers of B. tropicus were found. The

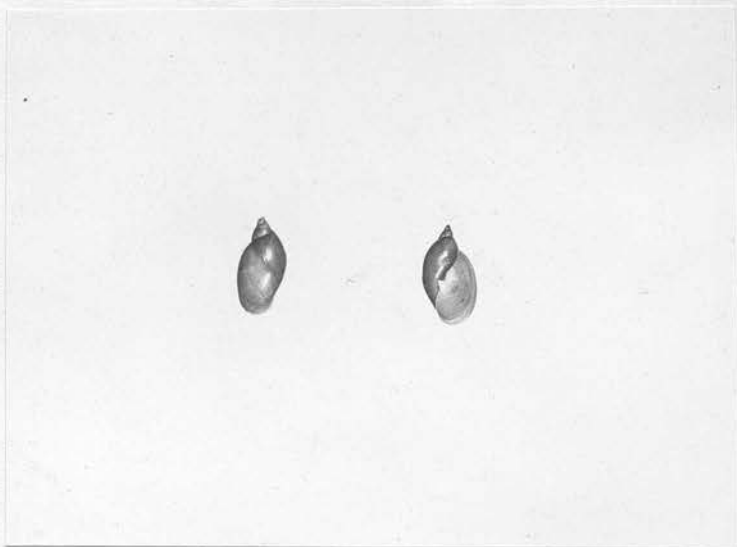


Plate XII

Lymnaea caillaudi (Bgt.)  
(Natural size).

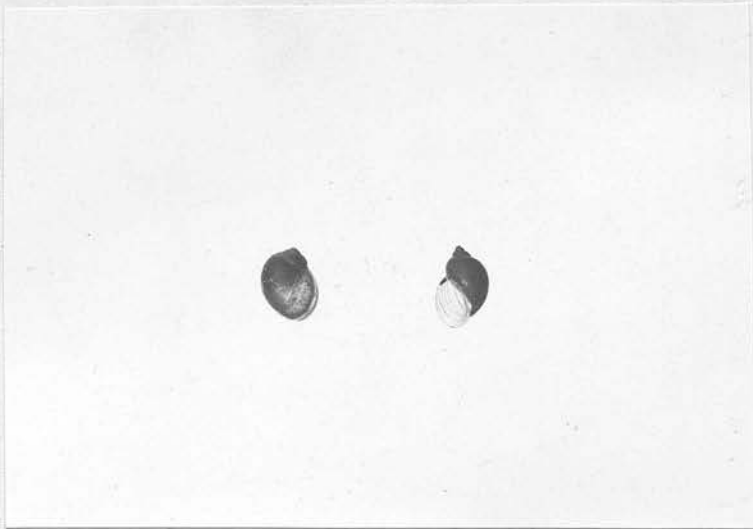


Plate XIII

Bulinus tropicus (Krs.)  
(Natural size).



Plate XIV

A small stream near Salisbury which  
contained large numbers of Bulinus  
tropicus.

photograph was taken early in the month of February during a break in the rains and shows a well-filled stream which rises from a small spring about a quarter of a mile higher up. In the course of the previous dry season this streamlet had dried up completely, yet three months after the onset of the rains it was found to be harbouring large numbers of B. tropicus. A systematic study of this streamlet would probably throw considerable light on the fate of B. tropicus during the dry season. A number of molluscs from this stream were placed in a jar practically full of slimy mud from the bed of the stream and exposed to gradual drying on the laboratory bench, but the snails showed no tendency to burrow down to moister levels. The explanation of how this stream came to acquire its molluscan population is still obscure. A certain number of snails may have retained their vitality through burying into the mud or in amongst the rootlets in the bank during the subsidence of the stream or the stream may acquire a fresh stock of molluscs each season from snail eggs carried by birds.

Bulinus natalensis (Plate XV) was found on the borders of a large heavily reeded marsh (the Nyamgai Marsh) containing large numbers of lotus plants particularly round the margins. The bottom of the





Plate XV

Bulinus natalensis (Krs.) var ?  
(Natural size).

Bulinus tuberculata (Plate XVI). No observations were made on the bionomics of this snail. The only specimens obtained were brought to the laboratory by a native hunter who had found them in a stream in the Kruger National Park (Brave district).

This species has a limited distribution in the region and specimens were obtained from the wild only during the course of the field investigations.

marsh was covered to a depth of several inches with a dark slimy mud. The snails appeared to be present in greatest concentration on the undersurface of lotus leaves overlying about 2 feet of water. Out in the centre of the marsh, snails were present but were very much harder to find. Furthermore, the temperature of the water was several degrees higher round the marginal zone than in towards the centre where the water was invariably unpleasantly cold.

No other molluscs were found in this marsh which was thus a great natural breeding ground for B. natalensis. Large numbers of egg-nests were found on the lotus leaves. Their configuration was essentially similar to those of Physopsis globosa although consistently smaller in size.

Melanoides tuberculata (Plate XVI). No observations were made on the bionomics of this mollusc. The only specimens obtained were brought to the laboratory by a Native who stated he had found them in a stream in the Fungwe Reserve (Mrewa district).

They appear to have a limited distribution in the Colony as no specimens were obtained from the wide area covered in the course of the field investigations.



Plate XVI

Melanoides tuberculata (Müll).  
(Natural size).

Potential intermediate Hosts: Repeated search was made for the presence of mammalian cercariae in specimens of B. tropicus and B. natalensis, but apart from the occurrence of an amphistome cercaria in a single B. tropicus, no other cercariae were found. In view of the fact that the genus Bulinus is the recognised carrier of S. haematobium in Egypt, the members of this genus found in Southern Rhodesia must necessarily be regarded as potential intermediate hosts, and for this reason, require further investigation.

Seasonal Variation in the Molluscan  
Content of Rivers and Streams  
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It has already been indicated that during the months of May, June and July, considerable difficulty was experienced in finding fresh-water molluscs even in pools which later in the season contained numerous specimens. It is now obvious that the experience was in accord with the seasonal variation that obtains in regard to the molluscan population of the rivers and streams of the Colony.

During the rainy season, flooding of the rivers and streams occurs at frequent intervals over a period of approximately five months. With the river in

flood, the bed and margins of the streams are subjected to the powerful scouring action of the flood waters, with the result that vast numbers of snails are swept out of the pools and carried towards the larger rivers. No doubt a certain proportion of snails is actually killed off in the process. By the end of the rainy season it seems likely that the molluscan population of the streams is considerably depleted, although numbers of molluscs might quite well persist in backwaters where flooding is of a more passive character, or a few may become impacted in the soft banks of a stream.

After the rains have passed and the flooding has ceased, the snail population of suitable parts of the stream gradually increases and by July and August has probably reached its maximum. It is probable that the chill night temperatures of the dry season exert an inhibitory influence on excessive increase in the snail content of the streams, but a more important factor is the gradual drying up of the water-ways. With the advance of the dry season the rivers and streams shrink rapidly and soon only a few residual pools remain frequently separated by long stretches of dry sand or gravel. In many of the pools, however, snails of various genera may be present in considerable concentration but the dessicated shells that lie scattered round the



margins bear evidence of the considerable mortality occasioned by the rapid shrinkage in the volume of the pool.

On the evidence obtained it seems reasonable to conclude that in Southern Rhodesia the molluscan content of the rivers and streams reaches its lowest level towards the end of the rainy season (February, March and April). After the rains have ceased and still stretches of water appear in the course of a stream the molluscs gradually increase in numbers, particularly in those pools containing luxuriant growths of lotus plants, and by about August they have probably reached their maximum number. Thereafter the extensive drying up of the water-ways and the subsequent floods are potent factors in reducing the snail content of the streams. The repopulation of a pool is still a matter of conjecture as the rate of growth of young snails and the burying propensities of adults have not yet been adequately studied.

#### Relative Incidence of the Various Molluscan Genera

The snail most universally distributed throughout the north and eastern half of Southern Rhodesia was found to be Lymnaea natalensis. Although not found

in the western half of the Colony, opportunities of searching for it in this area were too few to render a statement regarding its western distribution of any value. In a given locality, Lymnaea natalensis was usually found to be present in greater numbers than any other molluscs that might happen to be present.

The distribution of Physopsis globosa within the Colony was found to be approximately co-extensive with that of Lymnaea natalensis in the regions surveyed, but in most cases when the two were found, Physopsis was present in fewer numbers than Lymnaea.

Planorbis, Bulinus, Lymnaea caillaudi and Melanoides tuberculata all appear to have a patchy distribution. The places in which they were found during the investigation have been indicated above.

On keeping Fresh-water Molluscs under  
Laboratory conditions  
-----

It was found possible to keep fresh-water molluscs alive and active under laboratory conditions for several weeks and even months provided due attention was paid to the aeration of the watery medium and to the nature of the food supply.

The snails were placed in large glass tanks well

filled with tap-water and by means of a reciprocating water-driven air pump (of German design) air was bubbled through the tank continuously.

The molluscs were fed on fresh lettuce leaves which had been boiled in water until the fibrous structure of the leaf was rendered soft and pulpy. Each batch of snails received a fresh supply of boiled lettuce leaves twice a week. It was only necessary to change the water in the tanks once a fortnight or so, depending on the snail population of the tanks. Almost any number of tanks can be aerated from the one automatic pump.

When, for any reason, it was necessary to study a batch of snails individually, each snail was placed by itself in a large test-tube 6" x 1", about three-quarters full of water, together with a small piece of lettuce leaf. The practice adopted was to change the water in these tubes once a day, but it is doubtful if this procedure is to be recommended as it was rarely possible to keep snails alive for more than five or six weeks under these conditions. Snails survived for as long as five-and-a-half months in the tanks where the water was continuously aerated and changed only at fortnightly intervals. The factor responsible for the death of the snails was not accurately determined. It was thought that the hydrogen-ion ~~in~~ concentration of

the water was possibly the lethal factor but in snails dying after arrival in England, the tissues have been found infiltrated with a parasitic protozoan, the significance of which has not yet been fully assessed.

The experimental infection of Molluscs  
with Schistosome Miracidia

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The material containing the schistosome eggs was concentrated to some extent. In the case of urine, a large sample was obtained and allowed to stand for several hours on the laboratory bench. The greater part of the supernatant fluid was decanted off and the rest of the fluid concentrated by centrifugation. The concentrate was placed in a Petri dish, or in a glass capsule, according to the bulk of fluid used and was then well diluted with distilled water or tap-water and allowed to stand for one or two hours, or more. By the end of this period most of the viable miracidia had hatched and could be seen swimming actively under the dissecting microscope.

Faeces containing schistosome eggs was concentrated by straining and centrifugation. This material was allowed to stand over-night, or if put up early in the morning was not used until late in the afternoon. The supernatant fluid was pipetted off into glass capsules



to facilitate enumeration of the miracidia obtained.

When a batch of miracidia had been obtained they were counted under the dissecting microscope. To obviate hyperinfection, each snail was exposed to not more than four or five miracidia which were placed in the test-tube or tank containing the snails. The exposure lasted not less than twenty-four hours.

In positive experiments, cercariae were being shed 6 to 8 weeks after exposure of the snail to infection. Field investigations frequently prevented the interval from being accurately determined.

On the Transmission of Fresh-water Molluscs  
over long distances  
-----

At the close of the present investigation it was desired to convey a number of molluscs of different genera from Southern Rhodesia to London and after a few preliminary laboratory experiments, it was decided to carry the molluscs buried in slightly moistened sand contained in a large tin and several glass specimen tubes.

The sand was first carefully washed in tap-water to get rid of as much adhering organic material as possible and subsequently dried. A quantity of dried sand was then slightly moistened and placed in a glass



specimen tube (or other suitable receptacle) together with a number of snails. Prior to placing them in the sand, the snails were allowed to feed freely on freshly boiled lettuce and it was also customary to allow them to dry for a few hours before burial. It is important to avoid crowding a large number of molluscs into a given receptacle. For example, it was found that the survival rate was highest when not more than six molluscs were placed in a 3" x 1" specimen tube. The tube must be completely filled with sand and securely stoppered.

By this means a large number of fresh-water snails were conveyed to London from Southern Rhodesia and after a journey occupying 26 days, it was found that a mortality rate of not more than 10 per cent had occurred amongst the buried snails.

Schistosoma mattheei (Veglia & Le Roux 1929)  
in Man

=====

The first reference to the presence of cattle schistosomes in Southern Africa, was made by Cawston (1921). Adult schistosomes recovered from guinea-pigs experimentally infected with cercariae obtained from Physopsis africana (naturally infected) were

found by Professor R. T. Leiper to include specimens of S. bovis. In the same year, Cawston observed long, narrow, spindle-shaped eggs (201 $\mu$  to 236 $\mu$  in length by 60 $\mu$  to 70 $\mu$  in breadth) in the urine of a child and drew attention to the possibility of S. bovis invading the human host in South Africa. He has since reported several cases in which eggs resembling those of S. bovis have been present in the urine of Man in South Africa.

It should be noted, however, that in Cawston's cases the diagnosis was based on the morphological characters of the egg and as his figures indicate (1921) the egg approximates very closely, both in size and in outline, to the eggs of S. mattheei recovered from Man in Southern Rhodesia during the present investigation.

It is of interest to note that in the illustrations to his first communication on the endemic haematuria of the Cape of Good Hope, Harley (1864) depicts a perfect example of the egg of S. mattheei. He regarded such eggs as a type of B. capensis (S. haematobium) egg but it is obvious that he was dealing with a mixed infestation of S. haematobium and the schistosome of cattle and sheep in South Africa.

In 1929, Veglia and Le Roux, working in the Veterinary Research Department, Onderstepoort, South Africa,

described a new species of mammalian schistosome (S. mattheei) which, though closely related to S. bovis (Sonsino) Khalil 1924, differed in certain important morphological details and also in regard to the pathological lesions produced in sheep. The definitive hosts of S. mattheei were found to be sheep and cattle and by means of animal experiment, Le Roux showed that Physopsis africana var. globosa was capable of acting as intermediate host.

The main characters of the parasite recovered from sheep are as follows. (Veglia and Le Roux 1929)

The males measure 17 - 22 mm. in length, averaging 18 - 19.5 mm. (These measurements apply to worms allowed to die in normal saline and preserved in 70 per cent alcohol or 10 per cent formalin). With the sides unfolded the maximum diameter was about 1 mm.

Four to six testes are present with a seminal vesicle anterior to the testes and a short ejaculatory duct which opens in the middle line posterior to the ventral sucker and at the beginning of the gynaecophoric canal.

The inner surface of the canal is armed with spines while the dorsum is studded with numerous spine-bearing cuticular tubercles. The portion of the body anterior to the ventral sucker is smooth.

The alimentary canal, which begins as a continuation of the funnel-shaped depression of the anterior

sucker runs posteriorly and bifurcates on reaching the ventral sucker. The two intestinal caeca may fail to re-unite or they may unite close to the posterior extremity and bifurcate again to form two short caeca of unequal length. Bifurcation and re-union may occur three or four times before the alimentary canal ends either as a single caecum or as two short caeca.

The excretory system does not differ from that described for other schistosomes.

The females were found to average between 17 and 25 mm. in length.

The anterior and ventral suckers are curved with spines but are much reduced compared with those of the male. The rest of the body is smooth and uncurved.

The alimentary canal bifurcates immediately anterior to the ventral sucker and continues posteriorly as two caeca which re-unite in the posterior half of the worm and terminate within 0.1 mm. of the posterior extremity.

The uterus measures 8 - 9 mm. in length and contains from five to ninety-five eggs.

The ovary measures approximately 1 mm. in length with a maximum diameter of about 0.2 mm. and lies partially between the intestinal caeca immediately in front of their re-union.

The vitelline glands surround the posterior common



caecum and occupy practically the whole posterior half of the worm.

The excretory pore is subterminal.

The eggs in the uterus measure from  $92_{\mu} \times 40_{\mu}$  to  $170_{\mu} \times 44_{\mu}$ . Eggs passed in the faeces measure  $170_{\mu} \times 72_{\mu}$  to  $280_{\mu} \times 84_{\mu}$ . Average measurements being  $180 - 240_{\mu} \times 60 - 80_{\mu}$ . Eggs preserved in a portion of caecum measured  $160_{\mu} \times 60_{\mu}$  to  $200_{\mu} \times 80_{\mu}$ .

In both cattle and sheep S. mattheei has for its definitive site the smaller veins draining the small intestine and caecum. The parasite may be found localised at both higher and lower levels in the intestinal tract and also in the liver, pancreas and mesenteric glands, but in contra-distinction to S. bovis, it has not been found in the uro-genital organs. Thus in cattle and sheep the eggs of S. mattheei occur in the faeces only, whereas the eggs of S. bovis have been demonstrated in both urine and faeces of the same animals.

A full account of the pathogenesis of S. mattheei in relation to sheep is given by Le Roux (1929a).

From the viewpoint of preventive medicine it was of considerable importance to determine whether or not Man is capable of serving as a definitive host for S. mattheei. Le Roux (1929) examined two Native



Collectors who had given evidence of skin irritation after collecting snails from a pool responsible for the occurrence of S. mattheei in sheep. Although urine and faeces were examined at intervals up to three months from the time of exposure to cercarial invasion no evidence of infection could be found. In view of this experience, Le Roux (1929b) states - "Although these findings are perhaps by no means conclusive, they seem to disprove the possibility of man normally functioning as a definitive host for S. mattheei."

S. mattheei in Sheep and Cattle in  
Southern Rhodesia.

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The first step in the determination of the infestation of Man in Southern Rhodesia with S. mattheei consisted in ascertaining the presence of this parasite in the known definitive hosts - namely, cattle and sheep. A number of sheep and a small number of cattle were autopsied either at the Salisbury abattoir or at the Veterinary Research Department, Salisbury. The results may be summarised as follows:-

S. mattheei in sheep.

Number of examinations.....	167
" " positives.....	19
Percentage infested.....	11.3

S. mattheei in cattle.

Number of examinations.....	26
" " positives.....	8
Percentage infested.....	30.8

It should be noted that a certain proportion of the sheep examined had been imported from Bechuanaland. The others, however, represented the product of the Southern Rhodesian sheep farms. Infestations with S. mattheei were found in both lots of sheep, indicating that this schistosome is endemic not only in Southern Rhodesia, but also in Bechuanaland Protectorate. The infestations were, in the main, light in character. The wasting and serous effusions and fat necrosis, together with the severe intestinal lesions and hepatic cirrhosis described by Le Roux (1929a) were not found in the cases examined.

All the cattle autopsied or examined belonged to Southern Rhodesia and it is noteworthy that not only was S. mattheei commoner in these animals than in the sheep, but the infestations were also heavier. This difference in the relative infestation rates of sheep and cattle has been shown to be statistically valid and as will be indicated later, is a matter of some importance from the viewpoint of preventive medicine in Southern Rhodesia, where cattle are more numerous than sheep.

The Bechuanaland Native stated that he had observed haematobium S. mattheei in Man.

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Having ascertained that S. mattheei parasitised the sheep and cattle of the Colony, careful search was made for evidence of the parasite in Man. As a result, ten cases were found in a large series of examinations in which infestation with S. mattheei could be demonstrated. In eight of the ten cases, the diagnosis was based on the morphology and size of the egg, while in two cases, adult worms were recovered at autopsy. The morphology of the worms recovered conformed with the original description of S. mattheei in cattle and sheep (Veglia and Le Roux 1929). The cases parasitised with S. mattheei were all Native males and in addition to S. mattheei, they all harboured S. haematobium.

This series of ten cases was composed as follows:-

Indigenous Natives.....	4
Nyasaland           " .....	2
Northern Rhodesia Native....	1
Bechuanaland           " ....	1
Original locality Unknown...	2

As the Natives concerned had been resident in Southern Rhodesia for several months, it was not possible to determine how many of the infestations had been acquired beyond the borders of the Colony.

The Bechuanaland Native stated that he had first observed haematuria prior to entering Southern Rhodesia and in view of the occurrence of S. mattheei amongst the sheep of the Protectorate (see above) it is possible that he had acquired his double infestation before entering the Colony.

In the human host S. mattheei has as its definitive site the uro-genital organs particularly the wall of the urinary bladder. Invasion of the intestinal tract was not found in the present series of cases. On one occasion, however, a Native was found with S. mattheei eggs in his faeces. At first this was thought to be an example of an intestinal infestation, but on repeating the examination of the faeces on several consecutive days, no schistosome eggs could be found. On questioning the Native about his diet on the day preceding the initial examination the information was elicited that he had ingested a quantity of ox intestine in a half raw state. The supposition is, therefore, that the mattheei eggs in his faeces were derived from a piece of schistosome-infested ox intestine. This observation is of interest in that it shows that ingested schistosome eggs may traverse the intestinal tract without suffering material damage to their essential structure.

As already stated, in all ten cases, S. mattheei was found in association with S. haematobium and in most cases



the eggs of the latter were about twice as numerous in a given sample of urine as the eggs of the former. Similarly at autopsy, the dominant parasite was S. haematobium, but as all the parasites were not removed from the uro-genital organs the numerical relationship of the two species cannot be stated.

In view of the definitive site of S. mattheei in the human host the eggs of the parasite appear in the urine of infested individuals. The egg (Plate XVII) is an elongated, spindle-shaped object with a well-marked terminal spine which varies considerable in size and shape and in the manner in which it arises from the pole of the egg.

The egg of S. haematobium is illustrated in Plate XVIII to facilitate comparison with the egg of S. mattheei.

The miracidium occupies the central region of the egg leaving the constricted polar extremities free. As in the case of the egg of S. bovis, the polar regions are filled with a clear, colourless fluid (Khalil 1924).

The dimensions of the egg as it appears in the urine of Man were found to range from 210 - 240 $\mu$  in length by 40 - 70 $\mu$  in width. These measurements were made with the egg resting on the surface of a glass slide in a small quantity of urine but not covered with a cover-slip.





PlateXVII

The egg of S. mattheei in the urine  
of Man. ( X 200 ).

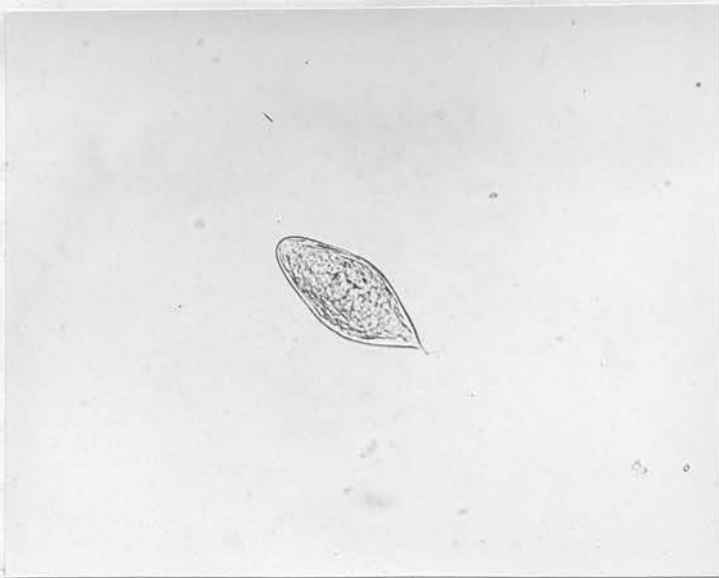


Plate XVIII

The egg of S. haematobium.  
(X200).

The schistosomes Pathological Lesions in S. haematobium  
and S. mattheei.  
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A detailed study of the pathogenicity of S. mattheei in the human host was not possible on the present occasion, the chief reason being that S. mattheei always occurred in association with S. haematobium. Material from two autopsies was obtained, the subjects being young Native males.

In one case the autopsy was performed for medico-legal purposes and although several schistosomes recovered from the vesical veins were kindly submitted to the laboratory for examination, no tissues were obtained. It was stated, however, that small sessile papillomata were present in the urinary bladder in association with considerable erosion of the mucous membrane. The schistosomes were identified as S. haematobium and S. mattheei.

The second case was a young Indigenous Native from Zimunya's Reserve, Umtali District, whose age was believed to be about 15 years. He was dead at the time of admission to hospital and in consequence it was not possible to ascertain whether or not he had presented any clinical evidence of urinary schistosomiasis. A number of schistosomes, together with the urinary bladder, was sent to the laboratory for investigation.

The schistosomes were identified as S. haematobium and S. mattheei.

#### The Urinary Bladder

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Macroscopic appearances: The wall of the urinary bladder was grossly thickened while the mucous membrane presented a coarsely granular appearance most marked posteriorly. The coarse granular appearance was due to the accumulations of small, flat, pale coloured papules. In places the papules had coalesced to form large, slightly raised plaques with a dark-brown irregular (ulcerated) surface, while at one point on the postero-lateral wall a pea-like papilloma projected into the bladder lumen. Extensive denudation of lining epithelium had occurred with the production of typical sandy patches. Apparently intact patches of mucous membrane were deeply congested

Microscopic appearances: The sections examined showed an extensive denudation of epithelium and ulceration of the subepithelial tissue, but at the same time epithelial downgrowths were readily demonstrable. The unusually large number of cell layers constituting the downgrowths provided striking evidence of the excessive epithelial proliferation occurring throughout the bladder as a whole. (Plate XIX

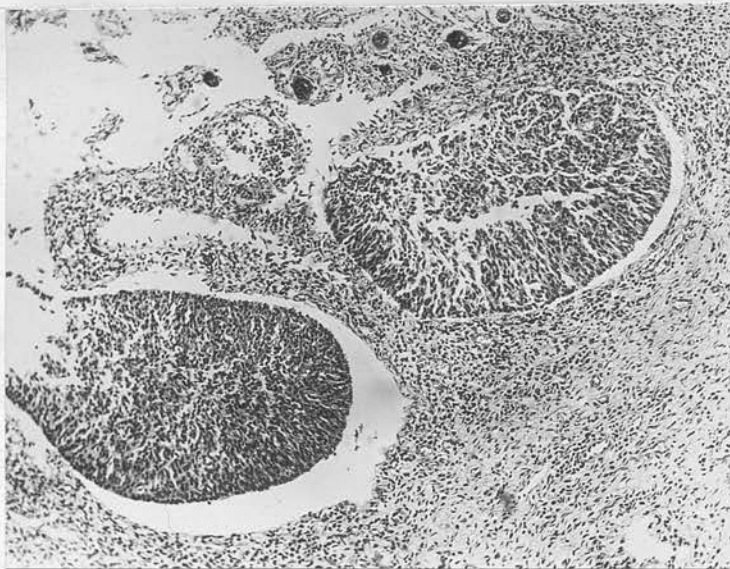


Plate XIX

Downgrowths of transitional epithelium  
occurring in response to Schistosoma  
invasion of the urinary bladder. ( X 80).



The submucous zone contained an abnormal amount of connective tissue together with a considerable load of schistosome eggs. More striking still, however, was the vast accumulation of cells in this area. Mononuclear cells and fibroblasts were present in considerable numbers, but the cell which dominated the picture was the eosinophile leucocyte. Enormous numbers of eosinophiles were distributed throughout the submucous area and with them were numerous multinucleated giant cells, all of which pointed to the fact that considerable miracidial activity was occurring in this area before death. In places the connective tissue and cell accumulations were heaped up to form papillomata.

The muscular layer showed an advanced degree of interstitial myositis, but in one of the sections masses of transitional epithelium were found situated within the muscular layer. (Plates XX and XXI).

Serial sections showed that these epithelial masses were quite independent of the epithelial downgrowths occurring all over the surface of the bladder. The epithelial masses were associated with numerous eggs and were shut off from the surrounding muscle by a zone of well-formed connective tissue. Eosinophiles again constituted a very high proportion of the cells

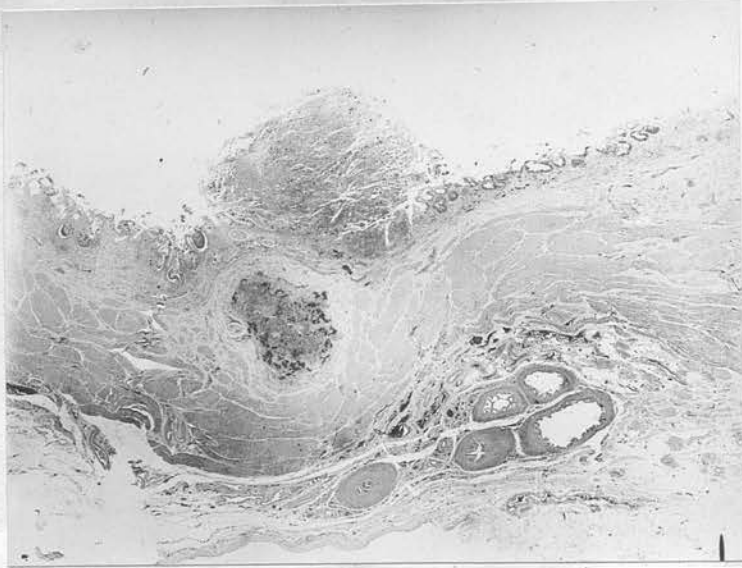


Plate XX

A low power view of the wall of the urinary bladder showing an accumulation of transitional epithelium in the muscular layer in addition to the well-marked lesions of schistosomiasis. (X 4.5).

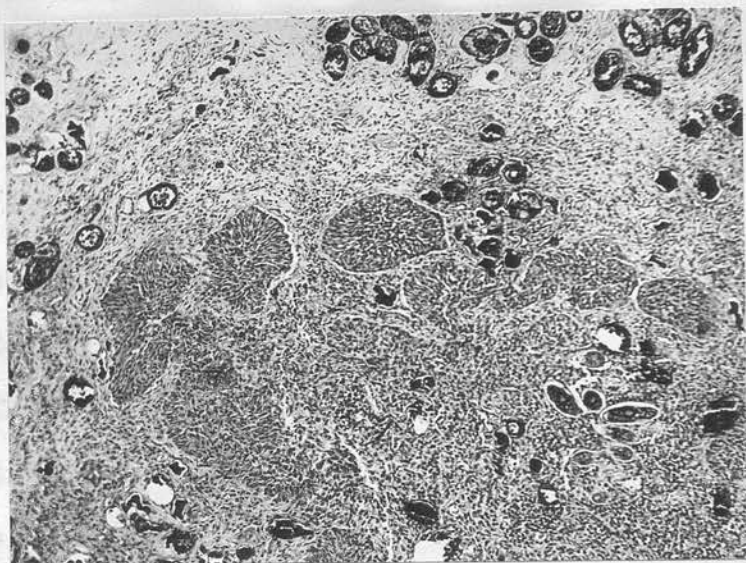


Plate XXI

A higher power view of the foci of transitional epithelium within the muscular layer of the urinary bladder. (X 80).

infiltrating the area enclosed by the connective tissue.

The subperitoneal tissues were intensely congested.

Several adult schistosomes were present in different parts of the section but chiefly in the submucous zone.

#### Interpretation of the Sections

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The material examined permits of a three-fold interpretation.

1. The extensive and well-established chronic interstitial myositis, together with an excess of submucous connective tissue found in relation to groups of calcified eggs, indicated a condition of chronic urinary schistosomiasis and probably represents the end results of an infestation acquired in childhood.

2. On the other hand, the intense eosinophilic infiltration in relation to focal accumulations of schistosome eggs suggests a recently acquired infestation, while the frequent occurrence of multinucleated giant cells is further evidence of secretory activity on the part of the miracidia. Direct evidence of active infestation is to be found in sections of normal schistosomes within the vesical veins.

3. Excessive epithelial proliferation constituted one of the most striking features of the sections, while the invasion of the muscular layer by masses of



transitional epithelium is an indication that a precancerous change had occurred.

Attention has been drawn to the occurrence of malignant disease as a complication of urinary schistosomiasis by Ferguson (1911) and more recently by Fairley (MSS. 1931). The occurrence of malignant disease as a complication of urinary schistosomiasis at the age of 5 years (Ferguson 1911) is an indication that the chronicity of the bilharzial lesion is not an essential factor in the production of neoplastic degeneration. An important observation in this connection was made by Fairley (1920) in the course of an experimental study of schistosomiasis in Rhesus monkeys. He found that within three months of exposure to infection, the wall of the urinary bladder presented a condition of extensive papillomatosis of bilharzial origin. Excessive epithelial proliferation with papillary outgrowths and downgrowths was one of the dominating features of the sections and although malignancy was not reported, certain of the sections presented features of a debatable character.

The present case is a further example of malignant changes complicating vesical schistosomiasis in a relatively young individual and emphasises the importance of diagnosing schistosomiasis at the earliest possible date.



The Intermediate Host  
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By means of animal experiments it was proved that in Southern Rhodesia, Physopsis globosa (see Plates I & II)

is the intermediate host of S. mattheei. The animals used in these experiments were guinea-pigs, rabbits, sheep and monkeys. The mode of exposure to infection has been described already. The material used was derived either from naturally infected snails or from snails which had been exposed to mattheei miracidia under experimental conditions. Snails to be used in infection experiments were kept under laboratory conditions for at least 8 weeks before being used.

Accurate observations were made on two specimens of Physopsis globosa exposed to mattheei miracidia. In both cases the mattheei eggs had been obtained from the faeces of a sheep. Both molluscs were exposed to the miracidia on the 7th July 1930 and maintained under laboratory conditions. In one case cercariae were seen for the first time on the 4th September 1930 and in the other case on the 16th September 1930, i.e.

56 days and 68 days respectively from the time of exposure to infection. The cercariae in these cases were fed to rabbits and sheep and adult S. mattheei worms eventually recovered.

It was found that in guinea-pigs the schistosomes were capable apparently of developing to adulthood, but did not appear to become sexually mature. Furthermore, in a number of instances guinea-pig experiments failed when positive results were obtained in other animals exposed to a similar infection at the same time. In rabbits development continued along normal lines and the adult schistosomes migrated into the vesicles of the small intestine. It was noted, however, that the female was invariably depositing unfertile eggs and in the absence of a miracidial secretion the eggs failed to reach the lumen of the intestine. In these experiments it was not possible to demonstrate eggs in the faeces of the infected rabbits.

Sheep, of course, were readily infected with S. mattheei. In one case eggs were demonstrated in the faeces for the first time 8 weeks and 4 days from the date of exposure to infection. Other sheep infected were not examined systematically. The animals had been bred at the Veterinary Research Department, Salisbury, and therefore could only acquire a schistosome infection under experimental conditions.

It was found that the small Gray Monkey, met with in Southern Rhodesia could also be infected with S. mattheei under experimental conditions. Two monkeys were successfully infected. The interesting point

is, that, whereas in man the parasite takes up its definitive site in the urinary bladder, in monkeys the infection involves the intestinal tract as in the case of cattle and sheep. The eggs passed by the monkeys contained viable miracidia.

#### Reservoir Hosts

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Cattle and Sheep: From the viewpoint of human medicine, cattle and sheep fall into the category of reservoir hosts of S. mattheei. Both sheep and cattle farming are carried on in Southern Rhodesia, but at the present time cattle probably constitute a more important reservoir for the parasite than do sheep. Cattle are more numerous than sheep, their life span is longer, and as teams of oxen are frequently employed in wagons, their movements are less restricted.

Baboons: (Papio porcarius). A total of 29 baboons were autopsied in the course of the investigation and in this series one baboon was found naturally infested with S. mattheei. The parasitised baboon was a young, half-grown male. The schistosomes were present in veins draining from the caecal region and from the small intestine. Numerous scrapings from the mucous membrane of the urinary bladder were examined for S. mattheei

eggs with negative results. It appears, therefore, that in the baboon, S. mattheei has its definitive site in the intestinal veins - particularly the veins of the small intestine.

As the animals had been dead two days before autopsy was performed, post-mortem autolysis had rendered the tissues unfit for histological examination.

Baboons are present in large numbers in most parts of Southern Rhodesia. They live in large families or troops amongst the rocky kopjes generally at some little distance from a Native kraal. During the maize growing season they make daily raids on the mealie fields, usually in the early morning, causing great depradation to the crops. In some cases it was noted that their only source of water supply was the pool used by the Natives. There is thus a relatively close association between the Native and baboon and as both have been shown to be capable of serving as definitive host for S. mattheei, the baboon must necessarily be regarded as a potential reservoir of the parasite.

Monkeys: Five grey monkeys (Cercopithecus pygerethrus) were autopsied but no evidence of schistosome infestation was found. As already mentioned, two monkeys were infected with S. mattheei under experimental conditions and as the parasites were able to reach maturity and



give rise to eggs containing viable miracidia, there is considerable likelihood of the parasite occurring naturally amongst the monkeys of the Colony.

Goats: The faeces from ten native goats were examined on one occasion, but no mattheei eggs found, but as sheep and goats have most parasites in common, it is also possible that the latter is capable of harbouring S. mattheei.



Commentary  
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The present investigation has established the fact that three species of schistosome parasitize Man in Southern Rhodesia. The species are:-  
S. haematobium, S. mansoni and S. mattheei.

The first of these constitutes the dominant schistosome infestation in the Colony in all sections of the community. It has been noted in the section that deals with the fresh-water molluscs of Southern Rhodesia that Physopsis globosa is one of the most widely distributed molluscs in the Colony and animal experiments have shown it to be the common intermediate host of S. haematobium. With S. haematobium endemic in the Native population, it is to be expected that urinary schistosomiasis will be more or less co-extensive with the distribution of the intermediate host and will thus become the dominant form of schistosomiasis.

On the other hand, Planorbis pfeifferi, the optimum carrier of S. mansoni, has not only a more patchy distribution, but is generally found in smaller numbers than Physopsis. These features of the distribution of Planorbis are reflected in the incidence of intestinal

schistosomiasis amongst the Indigenous Natives which is not only lower than the urinary form, but in a given district has a distinctly patchy distribution.

The presence of S. mattheei in Man in Southern Rhodesia is a matter of considerable importance from the viewpoint of preventive medicine. The parasite is apparently capable of existing in a variety of mammalian hosts since not only was it found in cattle and sheep, but also in the baboon, and grey monkeys could be readily infected. These mammals, therefore, constitute an enormous potential reservoir of the parasite and will serve to maintain the infection in the molluscan host. Even at present, parasitisation of the human host with S. mattheei is not a rare event in Southern Rhodesia and with the development of stock farming, there is a considerable likelihood of S. mattheei becoming a parasite of increasing importance in human medicine.

The subclinical character of schistosomiasis in Southern Rhodesia has served in large measure to minimise the importance of this disease as a health problem in the Colony. The evidence obtained in the course of the investigation has shown that while the invading schistosomes may be small in actual numbers, the amount of damage sustained by the host is far

vesical schistosomiasis constitute abundant reasons

greater than can be explained by the mere mechanical presence of the worms and their eggs.

It appears that the chief factors concerned in the production of the lesions of schistosomiasis are the toxic products of the worm and the secretory products of the miracidium, together with the mechanical presence of the parasite and its eggs. It is evident also that the intimate association between parasite and host affords ample opportunity for these factors to exert their deleterious influence. Almost at any time in the course of the disease secondary bacterial invasion is liable to constitute an important contributory factor in the production of the pathological lesions.

In addition to the well-marked pathological changes that characterise urinary and intestinal schistosomiasis it is possible that the continued diffusion of bilharzial toxin into the blood stream tends to impair the functional efficiency of the haemopoietic tissues and immunity response of the host in the presence of some intercurrent bacterial infection.

Apart from this hypothetical danger the pathological changes demonstrated in a series of cases of sub-clinical schistosomiasis, the possibility of vesical carcinoma or other genito-urinary complications in vesical schistosomiasis constitute abundant reasons

for utilising every available laboratory test in detecting the existence of active schistosomiasis as early as possible.

The small numbers of schistosomes recovered from those cases that came to autopsy, suggest that opportunities for acquiring massive infestations rarely, if ever, occur in Southern Rhodesia.

The molluscan population of a given pool was usually small compared with an area such as Egypt where vast numbers of snails abound in relation to the pools and irrigation canals. Furthermore, two important factors are constantly at work inhibiting the accumulation of molluscs in relation to suitable pools. On the one hand there is the rapid and widespread drying up of waterways during the prolonged dry season, and on the other, the scouring action of the flood waters during the rains. These factors maintain the molluscan content of pools at a low level and so lessen the chances of massive infestation.

No precise numerical observations were made on the infection rate amongst snails, but it probably varies very considerably in different localities.

The customs and beliefs of the Native of Southern Rhodesia do not expose him to the risk of acquiring fresh infestations at short intervals of time and thus offer a striking contrast to customs of the



Egyptian fellaheen which play an important rôle in determining the florid character of Egyptian schistosomiasis. In one instance the unusually high incidence of urinary schistosomiasis in a certain kraal was directly attributable to the resident Native requiring to make a weekly journey to a neighbouring chapel and as the path lay through a shallow pool containing several Physopsis snails, a high infestation ensued amongst this particular group of Natives.

It was found that opportunities for acquiring schistosomiasis varied considerably not only in different parts of the country but also at different seasons of the year.

Attention has already been drawn (page 40) to the differences that exist in the schistosome incidence amongst the Natives of different kraals in the same locality. The extensive drying up of waterways compel the Native to utilise whatever residual pool may exist in the proximity of his kraal. It was frequently observed while in the Darwin District that oxen and goats used the pool in common with the Native and children frequently paddled or bathed in the pool when commissioned to bring water. It is evident, therefore, that the presence of 'bilharzial snails' in a residual pool is likely to be associated with a relatively high



infestation rate amongst the Natives of the kraal it supplies.

Plate XXII illustrates a river bed in which no residual pools remained. In such cases the Natives dig pits in the sand or gravel and so obtain sufficient water for their daily requirements. As such pits are devoid of molluscs, infestation from this source is impossible during the dry season. With the flooding of the river during the rains conditions are again unfavourable to the existence of molluscs. In consequence Native Communities that obtain their water from flooded rivers during the rains and from pits dug in sand for the rest of the year, show a remarkably low incidence of schistosomiasis. The infestations that do exist in such communities have almost certainly been acquired in some other locality.

A study of the bionomics of the 'bilharzial snails' in Southern Rhodesia, render it highly probable that schistosome infestations are acquired more readily at one time of the year than at another. The progressive diminution in the volume of residual pools during the dry season leads to a gradual concentration of cercariae in those pools in which cercariae-producing snails survive. At this time of year the Native has little

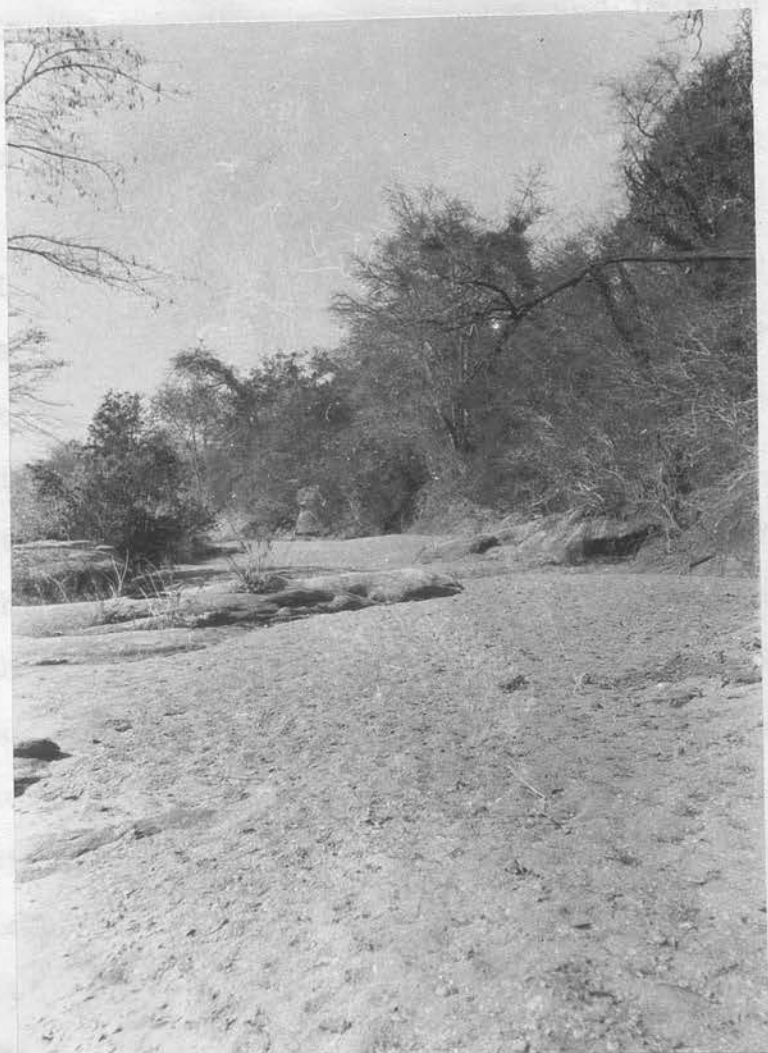


Plate XXII

An example of the dried up waterways from which Natives obtained water by digging pits in the gravel or sand.

choice in the matter of water supply and in many places he is obliged to utilise a pool with a relatively large snail population and in so doing, runs a considerable risk of acquiring some form of schistosomiasis.

During the dry season, Natives (particularly the males) show a greater tendency to wander further afield than they do during the rains and in their wanderings they drink freely from wayside pools.

Plate XXIII shows a Native drinking from a pool in which numerous *Physopsis* and *Planorbis* existed. The method of drinking consists in placing their mouth in direct contact with the water, or in scooping up the water in the palm of their hand. By either method they obtain the surface layers of water in which cercariae are likely to be present in greatest concentration.

Amongst the European population, camping and bathing occur with greater frequency during the dry season and for the reasons given, schistosome infestations are more likely to occur in this section of the population at this time than at any other season of the year.

During the rains, the floods flush out the residual pools, movement from place to place within the Colony is restricted, and foci of cercarial concentration no

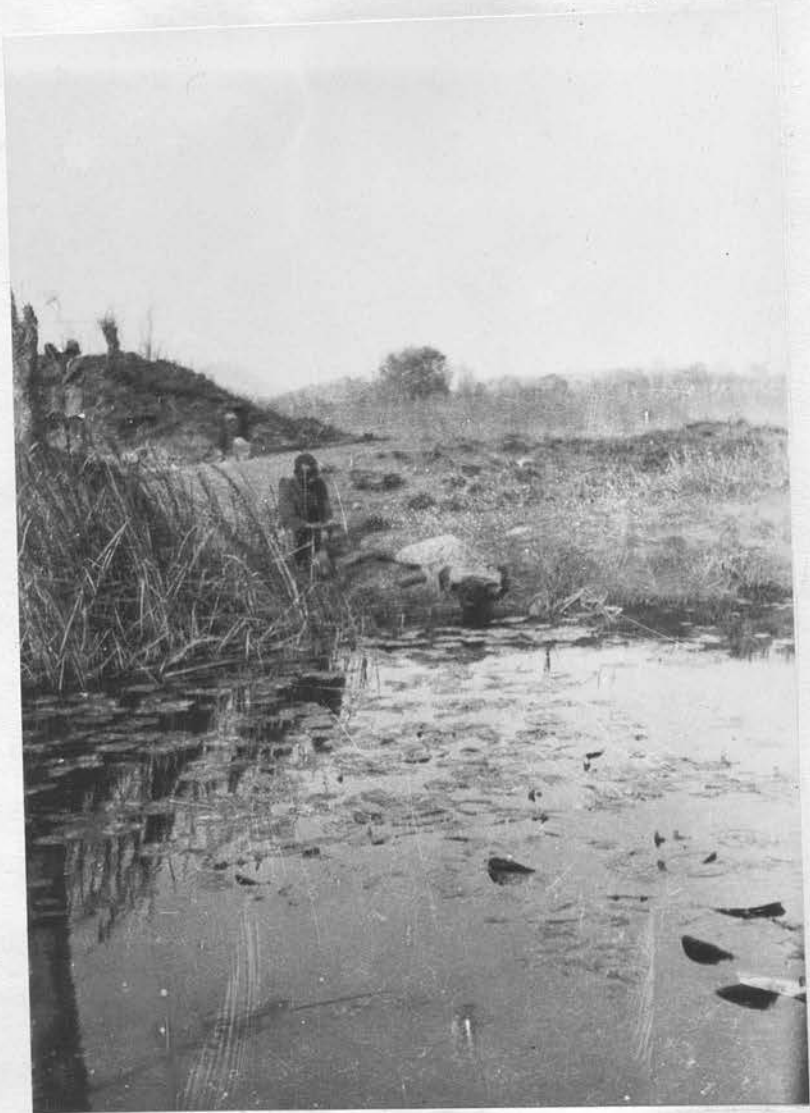


Plate XXIII

Natives drinking from a wayside pool  
containing both Physopsis globosa and  
Planorbis pfeifferi.

longer exist. It is probable, therefore, that the occurrence of schistosome infestation is at a minimum during the rains.

#### Prevention and Control

The prevention and control of schistosomiasis in Southern Rhodesia is beset with many difficulties. The country is large, the Indigenous Native population, in whom schistosomiasis is endemic, is widely distributed, while large numbers of parasitised Natives enter the Colony daily from adjoining territories. There is in addition, an enormous schistosome reservoir constituted not only by cattle and sheep, but also by baboons and possibly monkeys.

Christopherson (1928) advocates the use of tartar emetic as the most effective means of ridding the host of his schistosomes and of preventing infection of the intermediate host, but even allowing the practicability of the method, it makes no provision against the infection of snails by the reservoir hosts.

The study of the schistosome problem as it exists in Southern Rhodesia must, in the present state of our knowledge, inevitably lead to the conclusion that the most effective means of control lies in the eradication of the intermediate host.

The information obtained from a study of the bionomics of the schistosome carriers indicates that flooding on the



one hand and drying up of water-ways on the other, effect a certain measure of natural control and it seems a logical procedure to attempt to improve the efficiency of this line of attack by some means or another. It has been shown that as the dry season advances, molluscs become concentrated in residual pools of variable size and therefore the application of chemical substances destructive to the snail life of the pools is likely to act most effectively at this season (i.e. towards the end of the dry season).

Le Roux (1929b) found that copper sulphate in a dilution of 1 in 2,000,000 killed off all Physopsis africana var. globosa in eighteen hours, which suggests that this chemical might suitably be tried in the snail-containing residual pools of Southern Rhodesia.

It is obvious that although such measures must necessarily be restricted to certain localities in view of the enormous size of the Colony, a very large amount of schistosomiasis could be prevented, particularly amongst European children by the destruction of snails within a mile or two radius of the towns and townships. With a knowledge of the distribution of the intermediate hosts, Medical Officers could readily decide in which part of their district snail destruction is likely to prove most effective as a control measure and in this way gradually eliminate the main infective foci.

Following the administration of copper sulphate,

attempts may be made to clear the pools of vegetation, but as it has been shown that molluscs are able to survive in pools devoid of gross vegetation, this reason alone renders such measures of doubtful value in the eradication of the intermediate hosts.

Although tartar emetic may not constitute an effective means of eradicating schistosomiasis in Southern Rhodesia, it has a very definite place as an accessory control measure in virtue of its therapeutic efficacy.

In hospitals it should be made a rule to treat all cases of active schistosomiasis, whether in Natives or Europeans, whenever the clinical condition permits. The ability of the patient to receive his injections as an out-patient will rest with the clinician, but in regard to Natives, it is probable that hospital accommodation and conditions of employment will necessitate the establishing of a special out-patient department for the treatment of schistosomiasis.

Treatment of European schoolchildren is a matter of considerable importance. Not only would the disease come under treatment at an early stage, but, provided eradication of the snail hosts was being carried out systematically, re-infestation would be rare. Fairley's intradermal test for schistosomiasis could be utilised as a means of detecting possible cases of active schistosomiasis in schools where many practical

difficulties are in the way of routine examination of urine and faeces and cases showing positive reactions could be investigated further by means of the usual microscopical and, if need be, serological tests.

Finally, much useful preventive work could be carried out amongst Europeans and to a less extent amongst the Native races by the judicious dissemination of information pertaining to the biology of the mammalian schistosomes, the salient features of the disease they occasion in Man, and the need for early diagnosis and treatment.

#### SUMMARY

1. An account is given of the incidence of Schistosomiasis amongst the different sections of the population of Southern Rhodesia.
2. The intensity of the infestations amongst Natives is discussed, the subclinical character of the disease emphasised and a brief account given of the pathological changes met with in a series of Native autopsies.
3. The bionomics of the fresh-water mollusca of Southern Rhodesia are discussed and the intermediate hosts of S. haematobium and S. mansoni given.
4. The relationship of S. mattheei to human schistosomiasis is discussed, the common intermediate host of the parasite in Southern Rhodesia given and reference made to reservoir hosts.
5. The salient features of schistosomiasis in Southern Rhodesia are discussed and some observations made on the prevention and control of the disease.

APPENDIX A

The Cutaneous Lesions associated with the  
Penetration of Mammalian Cercariae

Four days -----  
An opportunity occurred of observing the skin reaction associated with skin penetration by certain mammalian cercariae.

While collecting specimens of Physopsis globosa from a residual pool in the course of the Umfuri River, near Mt. Darwin, an unusual tingling sensation was experienced over the dorsum of the right hand and in the vicinity of the wrist. The hand was immediately dried but the tingling sensation became more marked and assumed a burning character. Twenty to thirty minutes later the tingling had largely disappeared, but within an hour of the commencement of the phenomenon, a series of minute red macules were observed scattered over the dorsum of the hand and round the wrist. These macules of which there were 19 on the dorsum of the hand and wrist and 3 or 4 anteriorly, varied from 1 mm. to 1.5 mm. in diameter and were intensely red in colour. The appearance of the spots within a few hours of their development is illustrated in Plate XXIV.

Forty-eight hours later the macules could still be



observed but the red colour had lost its intensity and by allowing the light to fall obliquely across the hand the spots were noticed to be slightly raised above the surrounding skin surface.

Four days later the red colour had disappeared completely but the minute raised spots were definitely palpable - some more so than others.

Seven days later, three or four raised spots were still palpable but these soon subsided, so that at the end of ten days from the time of infection, no cutaneous lesions were visible.

Three weeks after the appearance of the skin lesions an opportunity occurred of applying Fairley's intra-dermal test for schistosomiasis. A strongly marked immediate reaction was obtained, followed by a well pronounced delayed reaction.

A diagnosis of urinary schistosomiasis was eventually established (the invading parasite being S. haematobium).

As the infective pool contained Physopsis globosa only, and as subsequent animal experiments showed that these molluscs were shedding cercariae of both S. haematobium and S. mattheei, it is reasonable to suppose that the cutaneous lesions were associated with the penetration of these cercariae although later examinations showed that if both species of cercariae penetrated, S. haematobium alone reached maturity.



APPENDIX B.

Anomalous Infestations  
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There are on record several instances in which S. mansoni and S. haematobium have failed to occupy the classical sites within the human host or have been more widely distributed than normally. Khalil (1926) records the occurrence of eggs of S. mansoni in the urine of 56 cases in a series of 7,090 examinations (0.8%) while 65 cases in 7,136 examinations (0.9%) showed eggs of S. haematobium in the faeces.

Suldey (1925) records an interesting case in which eggs of both schistosomes were found in urine and faeces.

Mixed infestations have been also recorded by Pomaret & Andreani-Constantine (1921), Khouri (1928), Fairbairn (1928) and others.

In a series of 758 examinations in a mixed Native community, a number of anomalous infestations were met with. In each instance the case was re-examined to exclude the possibility of a given specimen having been contaminated from other sources.

The cases may be summarised as follows:-

Eggs of <u>S. mansoni</u> in urine and faeces.....	1 case
" " <u>S. mansoni</u> in urine only.....	1 case
" " <u>S. haematobium</u> in urine and faeces....	4 cases
" " <u>S. haematobium</u> in faeces only.....	2 cases
" " <u>S. mansoni</u> and <u>S. haematobium</u> in faeces and <u>S. haematobium</u> in urine....	1 case
" " <u>S. mansoni</u> and <u>S. haematobium</u> in urine and faeces.....	1 case

The presence of haematobium eggs in the faeces need not necessarily indicate that the parasite is permanently resident in the intestinal veins. In order to reach its definitive site in the urinary bladder, S. haematobium travels via the capillary venous plexus around the rectum particularly through the perianal plexus and the junctional region of the superior and middle haemorrhoidal plexuses. It is, therefore, conceivable that a parasite advanced in maturity may deposit eggs during transit through these plexuses and that ultimately these eggs appear in the faeces. Thus a case of established urinary schistosomiasis with a recently acquired re-infestation may conceivably show eggs in both faeces and urine. Similarly, an individual recently infested may show haematobium eggs in the faeces and none in the urine. Therefore, before deciding that S. haematobium

has localised itself permanently in the rectal wall, a prolonged study of the case is necessary.

The occurrence of S. mansoni eggs in the urine probably indicates that local conditions in a certain section of the large intestine have made it necessary for the parasite to move further afield to find a suitable habitat in the wall of the urinary bladder. What these factors may be, however, is quite unknown.

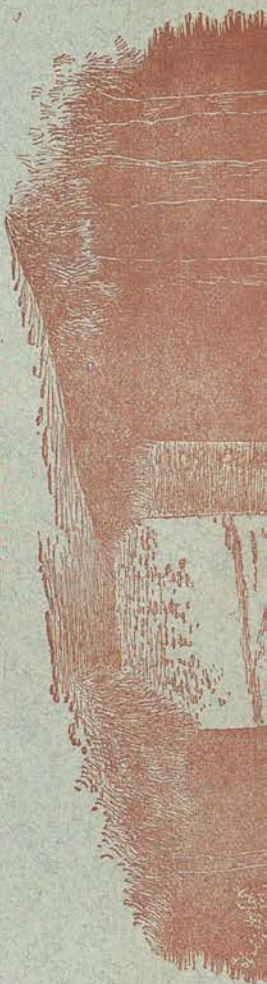


W. Mc DONALD  
1931

Plate XXIV

Skin lesions produced by mammalian  
schistosome cercariae.





WHATMAN'S  
WATER COLOUR SKETCHING BOARD.  
HOT PRESSED SURFACE.

No. 1		No. 7	
1	7½ by 5½	19	by 13.5 c.m.
2	9½ " 5½	28.5	" 14.6 "
3	11½ " 6½	30	" 15.8 "
4	10½ " 7½	27	" 19 "
5	11½ " 9½	30	" 23.5 "
6	15 " 7	38.2	" 17.8 "
		No. 15	
		by 10½	38.2 by 27 c.m.
		8 19½	" 11½ 47 " 80 "
		9 21½	" 15 54 " 86.2 "
		10 23½	" 18½ 59.8 " 47 "
		11 30	" 21½ 76.8 " 54 "

MADE IN ENGLAND

by

WINSOR & NEWTON, LTD.

SIZE OF THIS BOARD : 15 × 10½ INCHES.

Dimensions de la Carton, 38.2 x 27 c.m.



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